# NAVAL POSTGRADUATE SCHOOL
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# THESIS

FLOW GENERATION IN A NOVEL
CENTRIFUGAL DIFFUSER TEST DEVICE

by

Panagiotis Vidos

September 1983

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# Flow Generation in a Novel Centrifugal Diffuser Test Device

by

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## ABSTRACT

Recognition of the need to develop optimum diffusers for advanced centrifugal compressors, resulted in the design and manufacture of a novel low speed test facility for centrifugal diffuser testing. The CDTD was designed to allow the flow angle and wall boundary profiles into the test diffuser to be controlled by variable geometry in the flow generator. The present study reports on the design of the flow generator and the analysis of the internal flow using a NASA computer code (MERIDL). First test results are given and are compared with the results of a control volume analysis. The flow angle control technique was found to work effectively but to give somewhat smaller angles (by 4°) than were predicted. It was concluded that the information obtained would allow scaling of the device, however an analysis code was needed which would accept the real physical boundary conditions.

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## LIST OF SYMBOLS AND ABBREVIATIONS

| | |
|---|---|
| A | Cross sectional area for hydraulic diameter calculation |
| $A_{JW}$ | Total outflow area of one jet-wall ($A_{JW}$ = .059 $FT^2$) |
| $A_{SV}$ | Outflow cross sectional area of one SV ($A_{SV}$ = .000436 $FT^2$) |
| $A_{T1}$ | Total flow area out of the GC |
| $A_{T2}$ | Total flow area out of the diffuser |
| $A_{MIX}$ | Total mixing area per swirl vane |
| $A_i$ | Area at station (i) |
| CDTD | Centrifugal diffuser test device |
| C | Wetted perimeter for hydraulic diameter calculation |
| $C_F$ | Friction coefficient |
| $C_P$ | Pressure term (sudden expansion) |
| $C_\tau$ | Friction term |
| $d_h$ | Hydraulic diameter |
| $\vec{F}$ | Force |
| GC | Generating cylinder |
| IW | Total surface area of the inner walls of the CDTD |
| JW | Jet walls |
| $K_{b1}$ | Blockage factor at the outlet of the swirl vanes |
| $K_{b2}$ | Blockage factor at the inlet of the test section |
| $\ell$ | Spanwise length (variable of integration) |
| $L_1$ | Half exposed length of the generating cylinder ($2L_1 = \ell_1$) |
| $\ell_1$ | Exposed length of the generating cylinder (total jet-wall spacing) |

| | |
|---|---|
| $L_2$ | Half span of the test section ($2L_2 = \ell_2$) |
| $L_2^*$ | Initially designed half span of the test section ($2L_2^* = \ell_2^*$) |
| $\ell_2$ | Span of the test section |
| $\ell_2^*$ | Initially designed span of the test section |
| $\mathring{m}_i$ | Mass flow rate |
| $M_{aw}$ | Moment exerted on the wall surfaces by the air about the longitudinal axis of the CDTD |
| N | Number of corrugations per exposed length of the generating cylinder ($N = 19.104\ FT^{-1}$) |
| $\hat{n}$ | Outward normal unit vector |
| OC | Outer casing of the CDTD |
| $P_{KIEL}$ | Kiel probe |
| $P_{5H}$ | Five hole probe |
| $P_{S_{GC}}$ | Static pressure at the surface of the generating cylinder |
| $P_{S_{OC}}$ | Static pressure at the surface of the outer casing |
| $p_{t1}$ | Stagnation pressure at the outlet of the swirl vanes |
| $p'_{t1}$ | Stagnation pressure after jet mixing |
| $p_w$ | Normal stress on the non cylindrical surfaces of the swirl vanes |
| $p_1$ | Static pressure at the outlet of a swirl vane |
| $\bar{R}$ | Mean radius of the generating cylinder location ($\bar{R} = 19.1$ IN) |
| $R_H$ | Radius at the hub of the flow model |
| $R_h$ | Hydraulic radius |
| $R_S$ | Radius at the shroud of the flow model |
| Re | Reynolds number |
| $R_1$ | Radius at the surface of the generating cylinder |
| $R_2$ | Radius at the test section inlet |

| | |
|---|---|
| SV | Swirl vanes |
| TS | Test section |
| $\hat{t}$ | Tangential unit vector |
| $V_z$ | Axial velocity (at the z direction) |
| $V_{R_i}$ | Radial velocity component at station (i) |
| $V_i$ | Total velocity at station (i) |
| $\overline{V}_{IW}$ | Average velocity for the flow over the inner walls of the CDTD |
| $\overline{V}_{ij}$ | Area average velocity |
| $\overline{\overline{V}}_{ij}$ | Mass average velocity |
| $V_{\theta i}$ | Tangential velocity component at station (i) |
| $\overline{V}_1$ | Average velocity out of the swirl vanes |
| Z | Number of corrugations per revolution of the generating cylinder |
| z | Longitudinal (axial) direction |
| $\beta_i$ | Flow angle at station (i) |
| $\overline{\overline{\beta}}_2$ | Mass average flow angle at the test section |
| $\nu$ | Kinematic viscosity |
| $\rho_i$ | Density at station (i) |
| $\psi$ | Stream function |

## ACKNOWLEDGMENTS

The author would like to pay tribute to the inspiration and influence of Professor J.R. Erwin in the initiation and early phases of this study. Professor Erwin was the Naval Air Systems Command Visiting Research Professor in Aeronautics at the time of his passing on May 1st 1983. For the advice and association as professor and student, and for the personal association with his family, I express my gratitude.

# I. INTRODUCTION

Centrifugal compressors are currently used in gas turbine power units for turboprop aircraft, helicopters and auxiliary power production. The capability of achieving high pressure ratios per stage (12:1), and the simplicity of design & fabrication, are reasons for using centrifugal rather than axial stages in smaller engine types. The main disadvantage is the progressively lower efficiencies obtained as the pressure ratio is increased.

A major contributor to centrifugal compressor inefficiency is the performance of the diffuser which closely follows the impeller of the compressor. The purpose of the centrifugal diffuser is to convert most of the kinetic energy of the flow entering the diffuser vanes into static pressure, with the highest efficiency attainable.

The design of centrifugal diffusers is presently based mainly on experimental results for two dimensional and conical diffusers. While numerical methods are currently under development, computer solutions to viscous, three dimensional, unsteady, transonic flows, with adverse static pressure gradients are not yet available as verified tools to be used to optimize designs.

Centrifugal diffusers are currently tested only as components of high speed compressors or gas turbine engines.

This approach is very expensive and does not yield detailed, accurate information which is necessary to confirm design systems or to provide the basis for improved theoretical analysis.

A new test facility [Ref. 1] has been proposed and built, the so-called CDTD (Centrifugal Diffuser Test Device), which has as its main purpose the large scale, controlled simulation of the time-averaged inlet flow to centrifugal compressor diffusers. The device will allow the detailed evaluation of proposed diffuser geometries at an acceptable expense, and will permit validation of new computer analysis codes for diffusers operating in a fully subsonic flow regime.

This report deals only with the flow generation within the CDTD, the control of which was to be effected in a novel way. The flow was supplied through a central, swirl generating cylinder (GC) and the average angle of the flow into the diffuser under test, was to be controlled by covering or exposing more or less of the cylinder's length.

The design and the calculations on which the device was based, are given in Chapter II. In the same section are also described the results obtained of modeling the flowfield generation using the NASA computer code MERIDL [Ref. 2]. In order to use the code, in its standard form, artificial boundary conditions were used to obtain nearly representative conditions at the physical boundaries.

Selected results from the initial program of measurements, carried out on the CDTD, operating in effect without a diffuser, are given in Chapter III.

The flow angle control principle, was shown to work qualitatively, however the angle produced for a given exposed length of the central cylinder, were found to be less (by 5°-10°) than were predicted in the design calculations.

Reasons for the observed differences between design and test results are discussed in Chapter IV. It is shown (Appendix D) that a control-volume analysis of the flow generation, in which the geometry of the swirl generating cylinder surface, mixing and wall effects are included, can be used to predict the measured results.

It is concluded in Chapter V that by using the results of measurements to establish reasonable values for unknown factors in the control-volume analysis, a means of scaling the design is obtained.

Finally, it is recommended that an axi-symmetric, inviscid analysis of the flow generation, in which the physical boundary conditions are more properly represented, be carried out.

## II. CDTD DESIGN

### A. DESCRIPTION

The Centrifugal Diffuser Test Device (CDTD), is located in the Cascade Building (213) at the Turbopropulsion Laboratory complex of the Naval Postgraduate School. A view of the apparatus is shown in Fig. 1. A schematic is shown in Fig. 2.

The philosophy in the design of the CDTD was to provide a nearly tangentially-directed, uniform airflow from a large cylinder, have a minimum decrease in tangential velocity between the cylinder and the test diffuser (conserving angular momentum) while the exposed length of the cylinder would control the radial component of velocity and hence the average flow angle ($\beta_2$) entering the test diffuser.

The device consists of the following major components with their corresponding functions.

1. Perforated Cylinder (Fig. 2, Index 5)

The perforated cylinder serves as a major structural component of the CDTD, holds the north and south plates in parallel and concentric alignment and provides uniformly distributed air at low velocity around its periphery.

2. Generating Cylinder (Fig. 2, Index 10)

The generating cylinder is placed around the perforated cylinder and consists of the following components.

a. Central Section (Fig. 2, Index 12)

The central section is made of sets of small nozzles (not 2-D vanes as shown in the schematic) formed by pressing & bending sheet metal strips and soldering them to form a drum. A view of the complete section is shown in Fig. 3. The nozzles provide an almost tangential velocity which is controlled by the pressure supplied at the inlet.

b. North & South End Cylinders (Fig. 2, Index 11)

These support the central section. They each contain a short length of porous section inside of which cylindrical throttles (Fig. 2, Index 6) are arranged to slide. The throttles, operating separately, expose or cover the porous sections, so controlling the air supplied to the jet walls.

3. Jet Walls (Fig. 2, Index 3)

These are annular end walls containing nozzles distributed radially, so that nearly tangential injection is produced through them (the same nozzles as for the generating cylinder are used). By-pass air, depending on the throttle positioning is routed through the jet walls, to effect changes in the velocity distribution at the diffuser inlet. The jet walls are also the means for controlling the main airflow into the test section (TS). The mass flow through the swirl vanes, is controlled by moving the jet walls axially, and so exposing more or less of the swirl vane area. Thus the velocity profile and the average flow

angle ($\beta_2$) at the test section, are controlled by the jet walls and associated throttle positions.

4. Other Components

The outer casing (Fig. 2, Index 9) contains a contraction contour (Fig. 2, Index 8), which is designed to turn the flow into a radial, parallel-wall test section containing the diffuser vanes under test.

## B. DESIGN CALCULATIONS

The CDTD design calculations are presented in Appendix A. The concepts of continuity and conservation of angular momentum were applied to an incompressible, inviscid flow. The detailed geometry of the inlet surface and effects of friction were not considered.

Selected flow angles ($\beta_2$) and jet wall spacings ($L_2$), were input into the derived formulae, and the results are given in Table A1 and Figure 29.

## C. FLOW ANALYSIS

A FORTRAN computer program MERIDL [Ref. 2] was used to obtain a prediction of the flowfield generated by the CDTD.

Specifically, in the design phase the main interest was to investigate the velocity behavior along the contraction contour (Fig. 2, Index 8), in order to verify that the flow is turned without adverse deceleration ahead of the test vanes, into the diffuser.

MERIDL, besides its general applications for calculating flows through blade rows in turbomachines, can obtain solutions for flow in annular ducts without blades.

The flow must be essentially subsonic and the solution obtained is for two-dimensional axi-symmetric, compressible, shock free flow. Upstream and downstream flow conditions can vary from hub to shroud, and provision is made for an appropriate correction for loss of stagnation pressure.

The analysis consists of the solution of the simultaneous, non-linear, finite-difference equations for the stream function ($\psi$).

The following assumptions are made:

(1) The fluid is a perfect gas with constant specific heat $C_p$.

(2) The only forces along a hub-shroud orthogonal mesh line are those due to momentum and pressure gradient (viscous forces are neglected in that direction).

(3) There is no heat transfer.

(4) The upstream and downstream boundaries of the solution region are orthogonal to the streamlines.

(5) The stream function is zero at the hub and 1.0 at the shroud.

The program generates an orthogonal mesh in the space between the hub and the shroud, by dividing it into equal increments along several hub-shroud lines. Spline curves are fit through the resulting points to obtain the streamwise

orthogonals. The normal orthogonals are obtained by a predictor-corrector technique. The solution of the equations follows an iterative method with successive overrelaxation.

1. Flowfield Modelling

An equivalent flowfield to the one generated by the CDTD had to be formulated in order to overcome MERIDL's inability to accommodate the real physical boundary condition along the generating cylinder.

The author of Reference 2 was consulted and the geometric model shown in Fig. 4 was developed after appropriate calculations were carried out (Appendix B).

The inflow stream was introduced with a constant whirl ($R_\theta r$ = const.) far upstream of the TS. The channel height was doubled so that the streamlines, close to the region of the contraction contour, approximated the actual flow pattern generated by the device .

The input files to MERIDL (Appendix E) were generated and the program was run using the Naval Postgraduate School's IBM 370-3033 computer.

2. Results

Selected tabulated results (for $\psi$ = 0.0 and $\psi$ = 1.0) from the converged output files generated by MERIDL are given in Appendix F.

The TEKTRONIX 618 plotter was used to plot the streamlines of the computed flowfield (Fig. 5a). An enlargement of the area of main interest around the contraction contour is shown in Fig. 5b.

The relative velocity along the outer casing wall ($\psi$ = 1.0), for the selected runs, is shown plotted in Fig. 6. The flow appears to be accelerating in the region of the contraction contour (stations 14-23) and then begins to diffuse.

Finally in Figures 7 and 8 the velocity and the flow angle variations are shown plotted for the $\psi$ = 0.0 streamline from the surface of the GC ($R_1$ = 1.5833 FT) up to the TS inlet ($R_2$ = 2.1 FT). The velocity is seen to diffuse smoothly and the flow angle decreases to almost a constant value at the inlet station to the test vanes.

A check was made of the velocity and flow angle uniformity at the location of the GC. The results are given in Table 1. Values between stations were obtained by linear interpolation of the tabulated output from MERIDL. The results show that the conditions expected, at the surface of uniform velocity and angle, appear to have been achieved with a maximum deviation of .5% in the velocity and 2.4% in the flow angle ($\beta_1$) at outlet flow angles from 60° to 75°.

Comparisons of the predictions with measurements will be made when pressure taps have been installed along the outer casing and the contraction contour, as discussed in subsection III.A.2.

## III. PRELIMINARY TEST PROGRAM

Preliminary measurements were carried out as shown in Figure 9, using a short vaneless diffuser, obtained by replacing the plexiglass walls (Fig. 2, Index 13), with locally fabricated plywood walls (Fig. 9, Index 4). The walls ended at the intended location of the leading edge of the test vanes.

The data were taken using two pressure probes, one United Sensor 5-hole and one Kiel probe. Both probes were connected to a manometer board, inclined at a 30° angle for greater sensitivity.

### A. INSTRUMENTATION

#### 1. Installed for Preliminary Measurements

The instrumentation arrangement is indicated in Figure 9. The 5-hole probe (Fig. 9, Index 1) was attached to the south half of the outer casing which could rotate to facilitate circumferential measurements. The radial position of the probe corresponded to the leading edge of the test vanes ($R_2$ = 25"). The probe could traverse axially in order to obtain data for the total pressure and flow angle distributions, as well as for the velocity profile, produced across the outlet from the plywood walls (parallel to the main axis of the device).

The Kiel probe (Fig. 9, Index 5) was moved radially from the GC surface ($R_I$ = 19"), up to the intended location of the LE of the test vanes ($R_2$ = 25"), and axially (from wall to wall). The purpose of measurements inside the flow generator was specifically to obtain:

a. The flow mixing pattern out of the swirl vanes and from the GC up to the outer casing.

b. Wake visualization close to the surface of the GC.

c. The blockage factor ($K_{B_1}$) for the flow, at the exit of the nozzles.

2. <u>Not Installed for Preliminary Measurements</u>

A set of pressure taps was designed to be drilled on the contraction contour and on the outer casing, as shown in Figures 10a and 10b in order to obtain data to compare with the results generated using MERIDL.

The proposed arrangement is shown in Fig. 10a, drawn on the north (fixed) part of the apparatus. The circumferential tap distribution is indicated in Fig. 10b, for both rotating and fixed walls.

A tap size of .04 inches diameter (.001 m) was selected. Pressure data can be recorded using the laboratory's HP 3052 Data Acquisition System with Scanivalve interface.

B. PROGRAM OF MEASUREMENTS

The goals of the preliminary measurements were:

a. To verify the effectiveness of the flow control method,

b. To visualize the flowfield,

c. To verify circumferential symmetry,

d. To measure the total pressure and flow angle ($\beta_2$) distributions at the inlet to the test section.

A series of tests were conducted, at a plywood wall spacing of 2.62" (varying slightly circumferentially), at selected jet wall spacings and throttle settings. Probe measurements were also taken at various circumferential positions.

## C. RESULTS

Data from selected runs are presented in Tables 2 through 17.

The data obtained from the measurements were reduced using the methods of averaging derived in Appendix C. The averages were obtained assuming incompressible flow and using the equations for conservation of mass and angular momentum.

A computer program was developed, to carry out the required calculations. Spanwise (gapwise) integrations were accomplished using the subroutine DATINT from Reference 3.

From the computations,blockage factors ($K_{b_2}$), and mass averaged flow angles ($\bar{\bar{\beta}}_2$) were obtained at the inlet of the test section for various configurations of the apparatus.

# IV. DISCUSSION

## A. EXPERIMENTAL RESULTS

The initial results showed that:

1. The flow control method was working, but the flow angle was not affected as much as was expected by jet wall spacing changes.
2. The measured maximum average flow angle $\beta_2$ was less than the design angle of 70°.
3. The flowfield generated by the device was qualitatively as expected and mixing of the jets from the swirl vanes occurred very quickly.
4. Circumferential symmetry of the measured flow angle $\beta_2$ at the exit of the plywood walls was not achieved.

In trying to explain the results, the importance of the leak which was forced to occur at the interface of the GC surface and the jet walls, in all but the maximum ($\ell_1$ = 24.375"), spacings was examined. Table 2-9 gives data for $\ell_1$ = 24.375".

A survey with a tuft at minimum jet wall spacing ($\ell_1$ = 7.0") showed that significant axial component of velocity and a vortex flow were generated at the gap, as shown in Figure IV.1 below.

A vortical recirculation region was established near the jet wall, between the outer casing (higher static pressure region) and the generating cylinder surface (lower

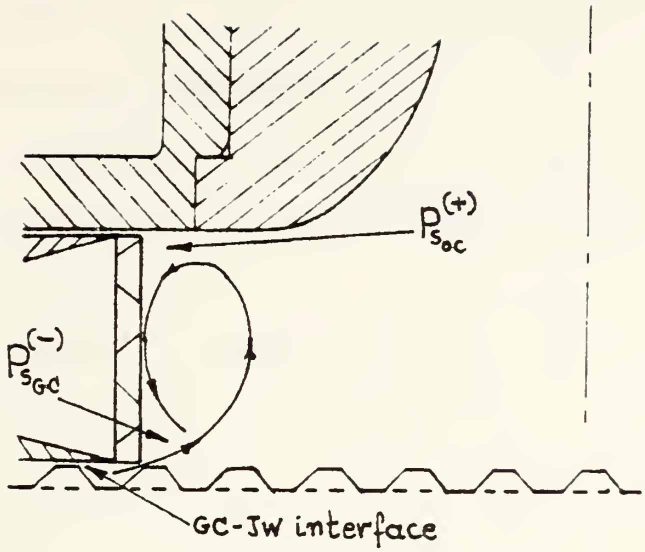



Figure IV.1. Schematic of the Vortex Flow Generated at the GC-JW Interface

static pressure region), which would contribute to a reduction in the total pressure and flow angle along the contraction cone. In addition, non-uniformity in the leak circumferentially, would result in non-uniformity in the circumferential measurements.

Sealing of the gap, using strips of upholstery piping, resulted in the data given in Tables 1-17. Noted were:

1. An increase in flow angle $\beta_2$ by approximately 4° (Figs. 11 and 12) and improvement in the total pressure distribution (Figs. 13 and 14).
2. Satisfactory circumferential uniformity in flow angle (Figs. 15 and 16) and total pressure (Figs. 17 and 18).

3. The effect of the jet wall spacing on $\beta_2$ (Fig. 19) approached more closely the design expectation (Fig. 29), the difference which remained will be discussed in the following subsection.

In Fig. 20 is shown the effect of JW spacing on the total pressure distribution at the location where the measurements were taken.

Figures 21 through 24 show the effect of the JW throttle setting on the flow angle (Figs. 21 and 22) and on the total pressure (Figs. 23 and 24), for the two JW spacings at which reliable (leak-free) measurements were taken

Figures 25 through 28 show circumferential measurements of the flow angle and the total pressure distributions for the jet walls in the fully retracted position.

## B. THEORY AND EXPERIMENT

In Fig. 29 are shown the results for the measured flow angle (averaged as described in Appendix C) and the values obtained in Appendix A, using the design calculation method, for the wall spacing at the time of the tests of 2.62". The experimental values are seen to be lower by 4° at maximum and 8° at minimum jet wall spacing.

The design calculation was based on an idealized flow-field and was immediately questioned. A complete control volume analysis (Appendix D) was carried out in order to take into account the geometry of the generating cylinder and the contributions of wall friction.

Examples of results are plotted in Fig. 29. The control volume analysis appears to agree well with the measured values when the JW's are widely spaced, but to predict a stronger effect of reducing the spacing than is actually measured. The significant differences between the idealized design predictions and the control volume analysis however, imply that the geometry of the generating cylinder surface and effects of friction need to be included in analyzing the flow. It is noted that the control volume analysis includes one unknown blockage factor, and one which must be input from measurements. Further examination needs to be made of the uncertainties in the analysis, in order to explain the differences in the slopes of the lines in Fig. 29.

Finally in Fig. 29 are shown the calculated flow angles corresponding to the design value of the diffuser wall spacing (2.0"). Clearly an increase of the wall spacing results in an increase of the flow angle. Any desired range of flow angle can be obtained by changing the width (or span) of the test diffuser.

## V. <u>CONCLUSIONS</u>

From the work reported, the following conclusions were drawn:

1. The proposed method of flow control works satisfactorily.
2. Sealing the jet wall gap is essential, in order to obtain the desired flow angles and circumferential flow symmetry. A method to provide sealing, at specific values of jet wall spacing must be designed in order to achieve the desired working range of diffuser inlet flow angle.
3. A review of the control volume analysis is necessary in order to explain the measured flow angles.
4. While results obtained with MERIDL were not unrealistic, the development of a computer code which will accept the proper boundary conditions, for the CDTD, is needed in order to predict more accurately the distributions of flow conditions at the test section inlet.

An advanced code with transonic flow capability is required ultimately for the design of a high speed version of the CDTD.

## TABLE 1

### FLOW CONDITIONS CALCULATED AT THE SURFACE OF THE GENERATING CYLINDER FOR MERIDL MODEL CHCK

| $\beta_i$ | 60° | | 65° | | 70° | | 75° | |
|---|---|---|---|---|---|---|---|---|
| SL | $V_1$ | $\beta_1$ | $V_1$ | $\beta_1$ | $V_1$ | $\beta_1$ | $V_1$ | $\beta_2$ |
| .00 | 220.17 | 83.41 | 229.86 | 84.71 | 237.92 | 85.92 | 244.26 | 87.06 |
| .05 | 220.46 | 83.01 | 230.11 | 84.35 | 238.14 | 85.59 | 244.45 | 86.75 |
| .1 | 220.69 | 82.59 | 230.28 | 83.99 | 238.14 | 85.27 | 244.57 | 86.48 |
| .15 | 220.87 | 82.21 | 230.41 | 83.67 | 238.34 | 85.02 | 244.53 | 86.27 |
| .20 | 221.08 | 88.81 | 230.54 | 83.34 | 238.37 | 84.78 | 244.24 | 86.09 |
| .25 | 221.39 | 81.26 | 230.75 | 82.90 | 238.56 | 84.44 | 244.69 | 85.85 |
| .30 | 221.78 | 80.64 | 231.02 | 82.40 | 238.72 | 84.06 | 244.80 | 85.59 |
| .35 | 222.14 | 80.07 | 231.27 | 81.95 | 238.12 | 83.71 | 244.87 | 85.34 |
| .40 | 222.44 | 79.60 | 231.53 | 81.57 | 239.18 | 83.41 | 244.94 | 85.11 |

UNITS

In Tables 1-17, velocity [V] is in ft/sec, angle [β] is in degrees, displacement (L2) is in inches and the reading of the inclined manometer (DP) showing the difference between impact and atmospheric pressure--is in inches of water.

TABLE 2 (WEST)

JW SPACING: 24.375 IN
THROTTLES: "OPEN"

| RUN | L2 | DP | BETA | V | VR | VT | VTM |
|---|---|---|---|---|---|---|---|
| CDTD28 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CDTD28 | .15 | 7.05 | 58.20 | 115.15 | 60.68 | 97.86 | 80.86 |
| CDTD28 | .35 | 10.55 | 54.60 | 140.86 | 81.60 | 114.82 | 127.57 |
| CDTD28 | .75 | 12.15 | 55.60 | 151.16 | 85.40 | 124.73 | 145.04 |
| CDTD28 | 1.25 | 11.85 | 56.80 | 149.29 | 81.74 | 124.92 | 139.04 |
| CDTD28 | 1.75 | 11.80 | 57.40 | 148.97 | 80.26 | 125.50 | 137.16 |
| CDTD28 | 2.15 | 11.05 | 58.20 | 144.16 | 75.97 | 122.52 | 126.73 |
| CDTD28 | 2.35 | 8.65 | 60.40 | 127.55 | 63.00 | 110.90 | 95.14 |
| CDTD28 | 2.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

AREA AVERAGED OVERALL VELOCITY 134.82
AREA AVERAGED RADIAL VELOCITY 73.44
MASS AVERAGED RADIAL VELOCITY 78.84
MASS AVERAGED TANGENTIAL VELOCITY 120.77
BLOCKAGE FACTOR .93
AVERAGED FLOW ANGLE 56.86

TABLE 3 (BOTTOM)

JW SPACING: 24.375 IN
THROTTLES: "OPEN"

| RUN | L2 | DP | BETA | V | VR | VT | VTM |
|---|---|---|---|---|---|---|---|
| CDTD29 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CDTD29 | .15 | 6.65 | 60.80 | 111.83 | 54.56 | 97.62 | 72.91 |
| CDTD29 | .35 | 9.70 | 57.20 | 135.07 | 73.17 | 113.53 | 113.71 |
| CDTD29 | .75 | 11.55 | 56.00 | 147.38 | 82.42 | 122.19 | 137.85 |
| CDTD29 | 1.25 | 11.30 | 56.20 | 145.78 | 81.10 | 121.14 | 134.48 |
| CDTD29 | 1.75 | 11.50 | 56.00 | 147.06 | 82.24 | 121.92 | 137.26 |
| CDTD29 | 2.15 | 10.55 | 55.00 | 140.86 | 80.79 | 115.39 | 127.62 |
| CDTD29 | 2.35 | 8.55 | 56.00 | 126.81 | 70.91 | 105.13 | 102.05 |
| CDTD29 | 2.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

AREA AVERAGED OVERALL VELOCITY 131.79
AREA AVERAGED RADIAL VELOCITY 73.05
MASS AVERAGED RADIAL VELOCITY 78.37
MASS AVERAGED TANGENTIAL VELOCITY 117.24
BLOCKAGE FACTOR .93
AVERAGED FLOW ANGLE 56.24

TABLE 4 (EAST)

JW SPACING: 24.375 IN
THROTTLES: "OPEN"

| RUN | L2 | DP | BETA | V | VR | VT | VTM |
|---|---|---|---|---|---|---|---|
| CDTD30 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CDTD30 | .15 | 5.40 | 68.40 | 100.78 | 37.10 | 93.70 | 51.02 |
| CDTD30 | .35 | 9.10 | 60.60 | 130.82 | 64.22 | 113.97 | 107.44 |
| CDTD30 | .75 | 11.40 | 59.00 | 146.42 | 75.41 | 125.51 | 138.93 |
| CDTD30 | 1.25 | 11.40 | 59.80 | 146.42 | 73.65 | 126.55 | 136.82 |
| CDTD30 | 1.75 | 11.88 | 57.80 | 149.47 | 79.65 | 126.48 | 147.88 |
| CDTD30 | 2.15 | 11.50 | 56.40 | 147.06 | 81.38 | 122.49 | 146.33 |
| CDTD30 | 2.35 | 9.80 | 56.80 | 135.76 | 74.34 | 113.60 | 123.95 |
| CDTD30 | 2.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

AREA AVERAGED OVERALL VELOCITY 132.53
AREA AVERAGED RADIAL VELOCITY 68.13
MASS AVERAGED RADIAL VELOCITY 74.00
MASS AVERAGED TANGENTIAL VELOCITY 121.85
BLOCKAGE FACTOR .92
AVERAGED FLOW ANGLE 58.73

TABLE 5 (TOP)

JW SPACING: 24.375 IN
THROTTLES: "OPEN"

| RUN | L2 | DP | BETA | V | VR | VT | VTM |
|---|---|---|---|---|---|---|---|
| CDTD31 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CDTD31 | .15 | 6.70 | 62.40 | 112.25 | 52.01 | 99.48 | 78.00 |
| CDTD31 | .35 | 10.05 | 58.00 | 137.48 | 72.85 | 116.59 | 128.06 |
| CDTD31 | .75 | 11.60 | 57.40 | 147.70 | 79.58 | 124.43 | 149.29 |
| CDTD31 | 1.25 | 11.10 | 58.00 | 144.48 | 76.56 | 122.53 | 141.44 |
| CDTD31 | 1.75 | 11.00 | 58.60 | 143.83 | 74.94 | 122.77 | 138.71 |
| CDTD31 | 2.15 | 9.20 | 60.00 | 131.54 | 65.77 | 113.92 | 112.96 |
| CDTD31 | 2.35 | 6.85 | 64.60 | 113.50 | 48.69 | 102.53 | 75.26 |
| CDTD31 | 2.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

AREA AVERAGED OVERALL VELOCITY 129.00
AREA AVERAGED RADIAL VELOCITY 66.33
MASS AVERAGED RADIAL VELOCITY 71.97
MASS AVERAGED TANGENTIAL VELOCITY 118.66
BLOCKAGE FACTOR .92
AVERAGED FLOW ANGLE 58.76

TABLE 6 (WEST)

JW SPACING: 24.375 IN
THROTTLES: CLOSED

| RUN | L2 | DF | BETA | V | VR | VT | VTM |
|---|---|---|---|---|---|---|---|
| CDTD37 | 0.00 | 0.00 | 90.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CDTD37 | .15 | 6.70 | 66.40 | 112.25 | 44.94 | 102.86 | 67.20 |
| CDTD37 | .35 | 10.50 | 60.00 | 140.53 | 70.26 | 121.70 | 124.29 |
| CDTD37 | .75 | 12.80 | 58.00 | 155.15 | 82.22 | 131.58 | 157.25 |
| CDTD37 | 1.25 | 12.55 | 59.00 | 153.63 | 79.13 | 131.69 | 151.46 |
| CDTD37 | 1.75 | 12.60 | 59.20 | 153.94 | 78.82 | 132.23 | 151.50 |
| CDTD37 | 2.15 | 11.30 | 60.40 | 145.78 | 72.01 | 126.76 | 132.67 |
| CDTD37 | 2.35 | 9.20 | 64.00 | 131.54 | 57.66 | 118.23 | 99.09 |
| CDTD37 | 2.62 | 0.00 | 90.00 | 0.00 | 0.00 | 0.00 | 0.00 |

AREA AVERAGED OVERALL VELOCITY 137.60
AREA AVERAGED RADIAL VELOCITY 68.80
MASS AVERAGED RADIAL VELOCITY 74.62
MASS AVERAGED TANGENTIAL VELOCITY 127.68
BLOCKAGE FACTOR .92
AVERAGED FLOW ANGLE 59.70

TABLE 7 (TOP)

JW SPACING: 24.375 IN
THROTTLES: CLOSED

| RUN | L2 | DF | BETA | V | VR | VT | VTM |
|---|---|---|---|---|---|---|---|
| CDTD38 | 0.00 | 0.00 | 90.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CDTD38 | .15 | 7.15 | 66.00 | 115.96 | 47.17 | 105.94 | 69.48 |
| CDTD38 | .35 | 11.15 | 60.00 | 144.81 | 72.40 | 125.41 | 126.26 |
| CDTD38 | .75 | 13.60 | 58.70 | 159.93 | 83.09 | 136.65 | 157.88 |
| CDTD38 | 1.25 | 13.10 | 59.00 | 156.96 | 80.84 | 134.54 | 151.24 |
| CDTD38 | 1.75 | 13.30 | 59.00 | 158.16 | 81.46 | 135.57 | 153.55 |
| CDTD38 | 2.15 | 12.65 | 59.40 | 154.24 | 78.52 | 132.76 | 144.95 |
| CDTD38 | 2.35 | 10.70 | 61.20 | 141.86 | 68.34 | 124.31 | 118.13 |
| CDTD38 | 2.62 | 0.00 | 90.00 | 0.00 | 0.00 | 0.00 | 0.00 |

AREA AVERAGED OVERALL VELOCITY 142.54
AREA AVERAGED RADIAL VELOCITY 71.92
MASS AVERAGED RADIAL VELOCITY 77.56
MASS AVERAGED TANGENTIAL VELOCITY 131.72
BLOCKAGE FACTOR .93
AVERAGED FLOW ANGLE 59.51

TABLE 8 (BOTTOM)

JW SPACING: 24.375 IN
THROTTLES: CLOSED

| RUN | L2 | DP | BETA | V | VR | VT | VTM |
|---|---|---|---|---|---|---|---|
| CDTD39 | 0.00 | 0.00 | 90.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CDTD39 | .15 | 8.70 | 62.00 | 127.91 | 60.05 | 112.94 | 87.24 |
| CDTD39 | .35 | 12.50 | 57.40 | 153.33 | 82.61 | 129.17 | 137.24 |
| CDTD39 | .75 | 13.95 | 57.40 | 161.97 | 87.27 | 136.46 | 153.16 |
| CDTD39 | 1.25 | 13.35 | 57.60 | 158.45 | 84.90 | 133.79 | 146.10 |
| CDTD39 | 1.75 | 13.55 | 57.80 | 159.64 | 85.07 | 135.08 | 147.80 |
| CDTD39 | 2.15 | 12.90 | 56.20 | 155.76 | 86.65 | 129.43 | 144.25 |
| CDTD39 | 2.35 | 10.50 | 57.40 | 140.53 | 75.71 | 118.39 | 115.28 |
| CDTD39 | 2.62 | 0.00 | 90.00 | 0.00 | 0.00 | 0.00 | 0.00 |

AREA AVERAGED OVERALL VELOCITY 145.27
AREA AVERAGED RADIAL VELOCITY 77.75
MASS AVERAGED RADIAL VELOCITY 83.23
MASS AVERAGED TANGENTIAL VELOCITY 130.94
BLOCKAGE FACTOR .93
AVERAGED FLOW ANGLE 57.56

TABLE 9 (EAST)

JW SPACING: 24.375 IN
THROTTLES: CLOSED

| RUN | L2 | DP | BETA | V | VR | VT | VTM |
|---|---|---|---|---|---|---|---|
| CDTD40 | 0.00 | 0.00 | 90.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CDTD40 | .15 | 8.45 | 66.20 | 126.06 | 50.87 | 115.34 | 83.05 |
| CDTD40 | .35 | 11.80 | 61.00 | 148.97 | 72.22 | 130.29 | 133.18 |
| CDTD40 | .75 | 14.30 | 59.40 | 163.99 | 83.48 | 141.16 | 166.78 |
| CDTD40 | 1.25 | 14.30 | 59.40 | 163.99 | 83.48 | 141.16 | 166.78 |
| CDTD40 | 1.75 | 14.45 | 60.00 | 164.85 | 82.43 | 142.77 | 166.55 |
| CDTD40 | 2.15 | 12.40 | 61.80 | 152.71 | 72.16 | 134.58 | 137.46 |
| CDTD40 | 2.35 | 9.10 | 66.20 | 130.82 | 52.79 | 119.70 | 89.44 |
| CDTD40 | 2.62 | 0.00 | 90.00 | 0.00 | 0.00 | 0.00 | 0.00 |

AREA AVERAGED OVERALL VELOCITY 145.70
AREA AVERAGED RADIAL VELOCITY 70.65
MASS AVERAGED RADIAL VELOCITY 76.86
MASS AVERAGED TANGENTIAL VELOCITY 136.66
BLOCKAGE FACTOR .92
AVERAGED FLOW ANGLE 60.64

## TABLE 10 (WEST)

JW SPACING: 8.0 IN
THROTTLES: CLOSED

| RUN | L2 | DP | BETA | V | VR | VT | VTM |
|---|---|---|---|---|---|---|---|
| CDTD81 | 0.00 | 0.00 | 90.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CDTD81 | .15 | 4.20 | 82.00 | 88.88 | 12.37 | 88.01 | 36.86 |
| CDTD81 | .35 | 4.90 | 80.80 | 96.00 | 15.35 | 94.76 | 49.25 |
| CDTD81 | .75 | 6.55 | 74.60 | 110.99 | 29.47 | 107.00 | 106.80 |
| CDTD81 | 1.25 | 8.65 | 67.60 | 127.55 | 48.60 | 117.92 | 194.08 |
| CDTD81 | 1.75 | 8.10 | 69.20 | 123.42 | 43.83 | 115.38 | 171.24 |
| CDTD81 | 2.15 | 5.15 | 75.40 | 98.42 | 24.81 | 95.24 | 80.00 |
| CDTD81 | 2.35 | 3.75 | 78.00 | 83.98 | 17.46 | 82.14 | 48.57 |
| CDTD81 | 2.62 | 0.00 | 90.00 | 0.00 | 0.00 | 0.00 | 0.00 |

AREA AVERAGED OVERALL VELOCITY 102.59
AREA AVERAGED RADIAL VELOCITY 29.53
MASS AVERAGED RADIAL VELOCITY 36.93
MASS AVERAGED TANGENTIAL VELOCITY 108.91
BLOCKAGE FACTOR .80
AVERAGED FLOW ANGLE 71.27

## TABLE 11 (TOP)

JW SPACING: 8.0 IN
THROTTLES: CLOSED

| RUN | L2 | DP | BETA | V | VR | VT | VTM |
|---|---|---|---|---|---|---|---|
| CDTD82 | 0.00 | 0.00 | 90.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CDTD82 | .15 | 3.00 | 79.00 | 75.11 | 14.33 | 73.73 | 39.54 |
| CDTD82 | .35 | 3.95 | 77.00 | 86.19 | 19.39 | 83.98 | 60.92 |
| CDTD82 | .75 | 6.45 | 71.00 | 110.14 | 35.86 | 104.14 | 139.71 |
| CDTD82 | 1.25 | 8.05 | 67.60 | 123.04 | 46.89 | 113.76 | 199.57 |
| CDTD82 | 1.75 | 6.45 | 73.20 | 110.14 | 31.83 | 105.44 | 125.58 |
| CDTD82 | 2.15 | 5.00 | 81.60 | 96.97 | 14.17 | 95.93 | 50.84 |
| CDTD82 | 2.35 | 4.05 | 84.60 | 87.27 | 8.21 | 86.89 | 26.70 |
| CDTD82 | 2.62 | 0.00 | 90.00 | 0.00 | 0.00 | 0.00 | 0.00 |

AREA AVERAGED OVERALL VELOCITY 97.34
AREA AVERAGED RADIAL VELOCITY 26.73
MASS AVERAGED RADIAL VELOCITY 34.54
MASS AVERAGED TANGENTIAL VELOCITY 103.93
BLOCKAGE FACTOR .77
AVERAGED FLOW ANGLE 71.62

## TABLE 12 (BOTTOM)

JW SPACING: 8.0 IN
THROTTLES: CLOSED

| RUN | L2 | DP | BETA | V | VR | VT | VTM |
|---|---|---|---|---|---|---|---|
| CDTD83 | 0.00 | 0.00 | 90.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CDTD83 | .15 | 4.00 | 80.80 | 86.73 | 13.87 | 85.62 | 40.71 |
| CDTD83 | .35 | 4.80 | 78.40 | 95.01 | 19.10 | 93.07 | 60.97 |
| CDTD83 | .75 | 6.55 | 73.60 | 110.99 | 31.34 | 106.47 | 114.41 |
| CDTD83 | 1.25 | 8.25 | 68.20 | 124.56 | 46.26 | 115.65 | 183.45 |
| CDTD83 | 1.75 | 7.50 | 71.40 | 118.77 | 37.88 | 112.56 | 146.22 |
| CDTD83 | 2.15 | 5.80 | 76.00 | 104.44 | 25.27 | 101.34 | 87.80 |
| CDTD83 | 2.35 | 4.75 | 78.00 | 94.52 | 19.65 | 92.45 | 62.30 |
| CDTD83 | 2.62 | 0.00 | 90.00 | 0.00 | 0.00 | 0.00 | 0.00 |

AREA AVERAGED OVERALL VELOCITY 102.64
AREA AVERAGED RADIAL VELOCITY 29.16
MASS AVERAGED RADIAL VELOCITY 34.63
MASS AVERAGED TANGENTIAL VELOCITY 107.62
BLOCKAGE FACTOR .84
AVERAGED FLOW ANGLE 72.16

## TABLE 13 (EAST)

JW SPACING: 8.0 IN
THROTTLES: CLOSED

| RUN | L2 | DP | BETA | V | VR | VT | VTM |
|---|---|---|---|---|---|---|---|
| CDTD84 | 0.00 | 0.00 | 90.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CDTD84 | .15 | 4.10 | 82.00 | 87.81 | 12.22 | 86.96 | 38.03 |
| CDTD84 | .35 | 5.05 | 80.00 | 97.46 | 16.92 | 95.97 | 58.13 |
| CDTD84 | .75 | 7.10 | 73.60 | 115.55 | 32.63 | 110.85 | 129.44 |
| CDTD84 | 1.25 | 8.65 | 68.40 | 127.55 | 46.95 | 118.59 | 199.28 |
| CDTD84 | 1.75 | 6.95 | 70.60 | 114.33 | 37.98 | 107.84 | 146.56 |
| CDTD84 | 2.15 | 4.35 | 77.20 | 90.45 | 20.04 | 88.20 | 63.25 |
| CDTD84 | 2.35 | 3.50 | 80.80 | 81.13 | 12.97 | 80.09 | 37.18 |
| CDTD84 | 2.62 | 0.00 | 90.00 | 0.00 | 0.00 | 0.00 | 0.00 |

AREA AVERAGED OVERALL VELOCITY 100.74
AREA AVERAGED RADIAL VELOCITY 27.94
MASS AVERAGED RADIAL VELOCITY 35.03
MASS AVERAGED TANGENTIAL VELOCITY 107.74
BLOCKAGE FACTOR .80
AVERAGED FLOW ANGLE 71.99

TABLE 14 (EAST)

JW SPACING: 8.0 IN
THROTTLES: OPEN

| RUN | L2 | DP | BETA | V | VR | VT | VTM |
|---|---|---|---|---|---|---|---|
| CDTD86 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CDTD86 | .15 | 4.40 | 81.80 | 90.97 | 12.97 | 90.04 | 32.01 |
| CDTD86 | .35 | 5.95 | 77.20 | 105.78 | 23.44 | 103.15 | 66.24 |
| CDTD86 | .75 | 9.80 | 70.00 | 135.76 | 46.43 | 127.57 | 162.30 |
| CDTD86 | 1.25 | 11.40 | 67.40 | 146.42 | 56.27 | 135.18 | 208.42 |
| CDTD86 | 1.75 | 10.00 | 69.00 | 137.14 | 49.15 | 128.03 | 172.40 |
| CDTD86 | 2.15 | 5.85 | 74.50 | 104.89 | 28.03 | 101.08 | 77.63 |
| CDTD86 | 2.35 | 5.20 | 78.80 | 98.89 | 19.21 | 97.01 | 51.06 |
| CDTD86 | 2.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

AREA AVERAGED OVERALL VELOCITY 116.57
AREA AVERAGED RADIAL VELOCITY 36.50
MASS AVERAGED RADIAL VELOCITY 44.56
MASS AVERAGED TANGENTIAL VELOCITY 123.43
BLOCKAGE FACTOR .82
AVERAGED FLOW ANGLE 70.15

TABLE 15 (BOTTOM)

JW SAPCING: 8.0 IN
THROTTLES: OPEN

| RUN | L2 | DP | BETA | V | VR | VT | VTM |
|---|---|---|---|---|---|---|---|
| CDTD87 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CDTD87 | .15 | 5.65 | 81.60 | 103.08 | 15.06 | 101.98 | 40.60 |
| CDTD87 | .35 | 7.05 | 78.00 | 115.15 | 23.94 | 112.63 | 71.29 |
| CDTD87 | .75 | 9.55 | 70.00 | 134.02 | 45.84 | 125.94 | 152.62 |
| CDTD87 | 1.25 | 11.05 | 67.40 | 144.16 | 55.40 | 133.09 | 194.95 |
| CDTD87 | 1.75 | 9.75 | 68.00 | 135.41 | 50.73 | 125.55 | 168.40 |
| CDTD87 | 2.15 | 6.15 | 72.40 | 107.55 | 32.52 | 102.51 | 88.14 |
| CDTD87 | 2.35 | 4.60 | 74.00 | 93.01 | 25.64 | 89.41 | 60.61 |
| CDTD87 | 2.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

AREA AVERAGED OVERALL VELOCITY 117.12
AREA AVERAGED RADIAL VELOCITY 37.82
MASS AVERAGED RADIAL VELOCITY 44.69
MASS AVERAGED TANGENTIAL VELOCITY 121.62
BLOCKAGE FACTOR .85
AVERAGED FLOW ANGLE 69.82

TABLE 16 (WEST)

JW SPACING: 8.0 IN
THROTTLES: OPEN

| RUN | L2 | DP | BETA | V | VR | VT | VTM |
|---|---|---|---|---|---|---|---|
| CDTD88 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CDTD88 | .15 | 3.30 | 82.20 | 78.78 | 10.69 | 78.05 | 22.20 |
| CDTD88 | .35 | 4.95 | 78.00 | 96.49 | 20.06 | 94.38 | 50.36 |
| CDTD88 | .75 | 9.60 | 69.60 | 134.37 | 46.84 | 125.94 | 156.90 |
| CDTD88 | 1.25 | 11.85 | 67.10 | 149.29 | 58.09 | 137.52 | 212.49 |
| CDTD88 | 1.75 | 11.05 | 68.60 | 144.16 | 52.60 | 134.22 | 187.79 |
| CDTD88 | 2.15 | 7.90 | 74.60 | 121.89 | 32.37 | 117.51 | 101.18 |
| CDTD88 | 2.35 | 5.95 | 78.80 | 105.78 | 20.55 | 103.77 | 56.71 |
| CDTD88 | 2.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

AREA AVERAGED OVERALL VELOCITY 118.79
AREA AVERAGED RADIAL VELOCITY 37.60
MASS AVERAGED RADIAL VELOCITY 46.51
MASS AVERAGED TANGENTIAL VELOCITY 126.62
BLOCKAGE FACTOR .81
AVERAGED FLOW ANGLE 69.83

TABLE 17 (TOP)

JW SPACING: 8.0 IN
THROTTLES: OPEN

| RUN | L2 | DP | BETA | V | VR | VT | VTM |
|---|---|---|---|---|---|---|---|
| CDTD89 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CDTD89 | .15 | 5.50 | 80.00 | 101.70 | 17.66 | 100.16 | 47.09 |
| CDTD89 | .35 | 7.10 | 76.00 | 115.55 | 27.96 | 112.12 | 83.44 |
| CDTD89 | .75 | 9.85 | 69.40 | 136.11 | 47.89 | 127.40 | 162.42 |
| CDTD89 | 1.25 | 11.10 | 66.80 | 144.48 | 56.92 | 132.80 | 201.23 |
| CDTD89 | 1.75 | 8.95 | 68.40 | 129.74 | 47.76 | 120.63 | 153.37 |
| CDTD89 | 2.15 | 5.40 | 73.20 | 100.78 | 29.13 | 96.47 | 74.81 |
| CDTD89 | 2.35 | 3.75 | 77.00 | 83.98 | 18.89 | 81.83 | 41.15 |
| CDTD89 | 2.62 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

AREA AVERAGED OVERALL VELOCITY 114.87
AREA AVERAGED RADIAL VELOCITY 37.56
MASS AVERAGED RADIAL VELOCITY 44.82
MASS AVERAGED TANGENTIAL VELOCITY 120.41
BLOCKAGE FACTOR .84
AVERAGED FLOW ANGLE 69.58

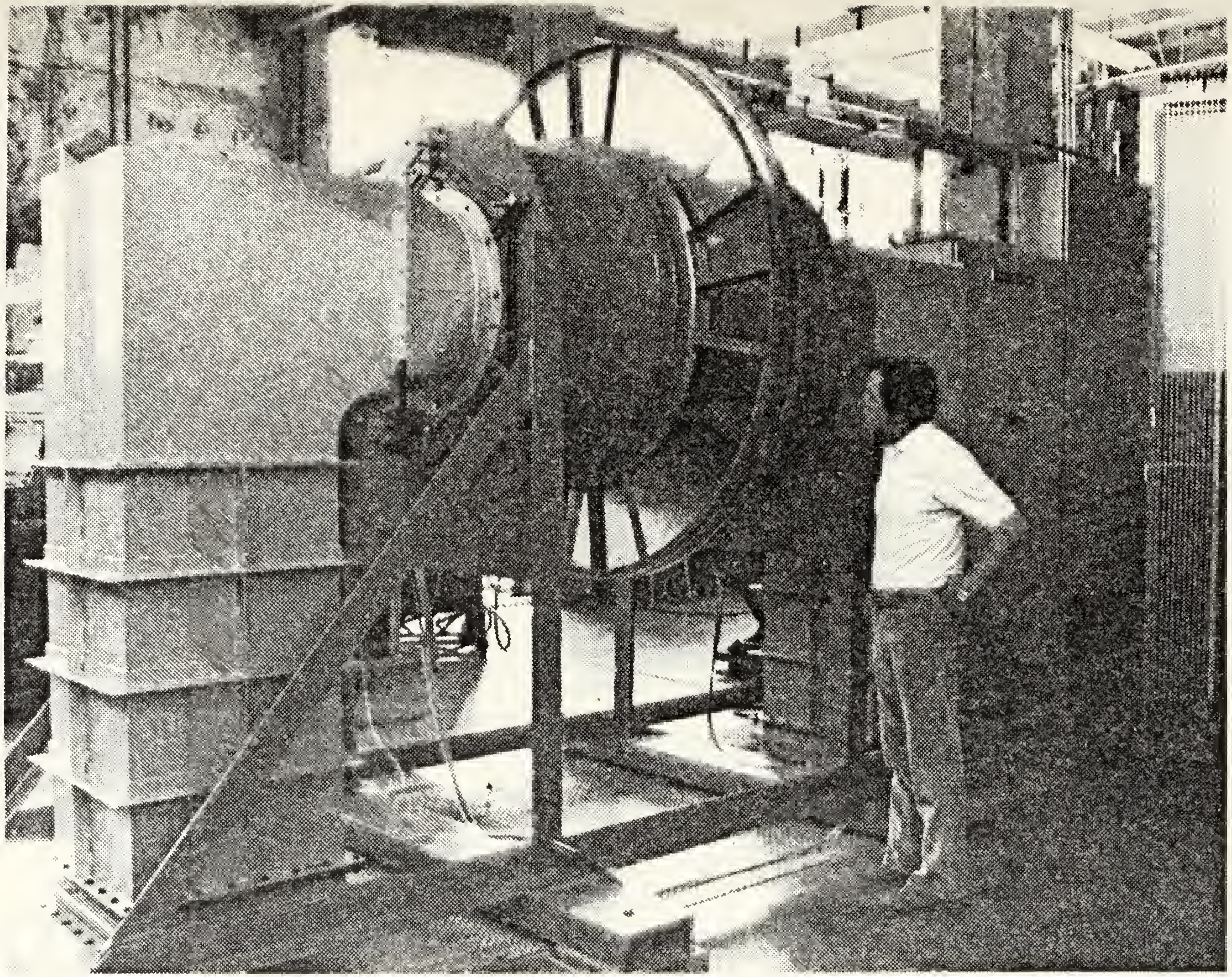


Figure 1.  View of the CDTD

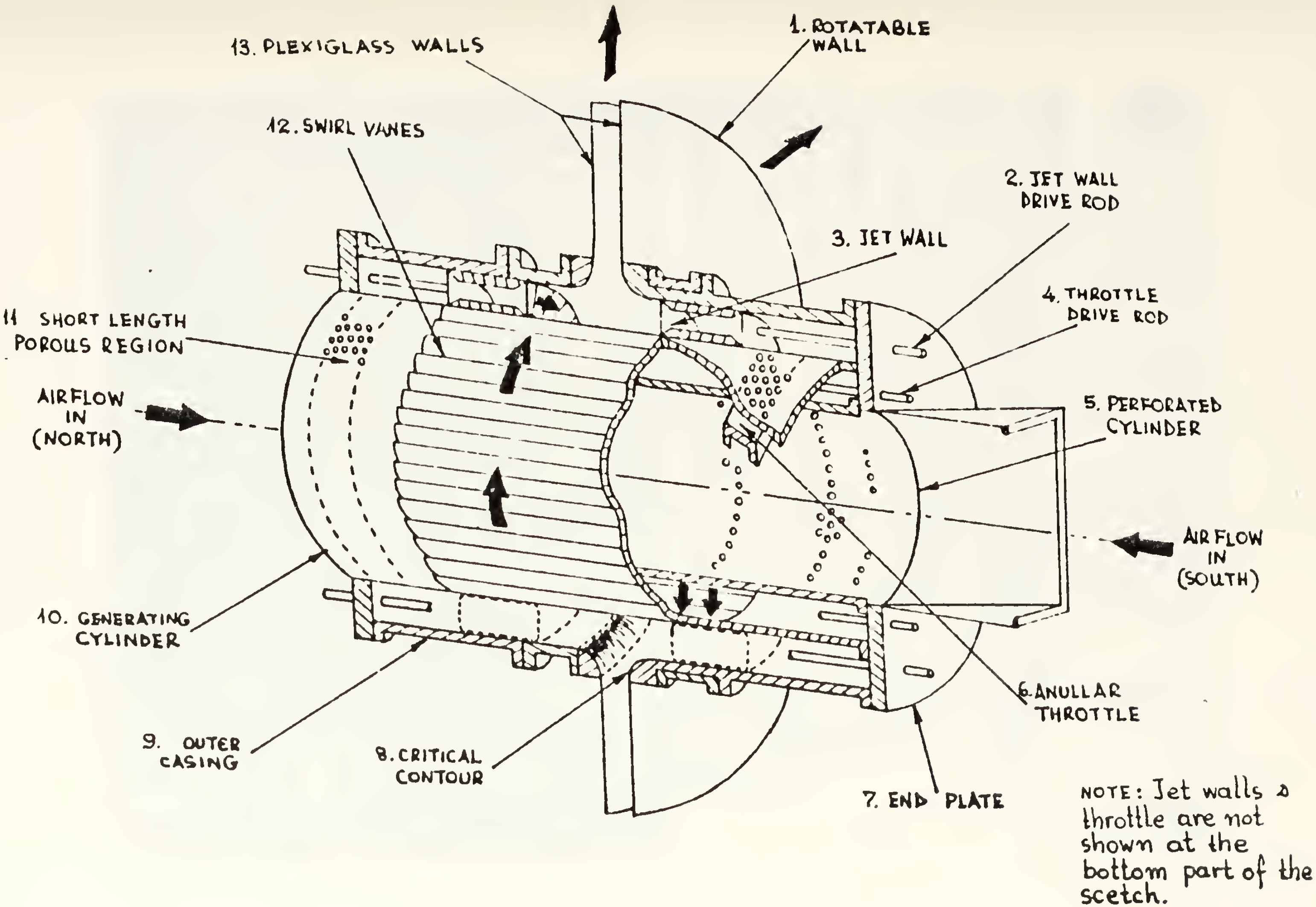



Figure 2. Schematic of CDTD Components

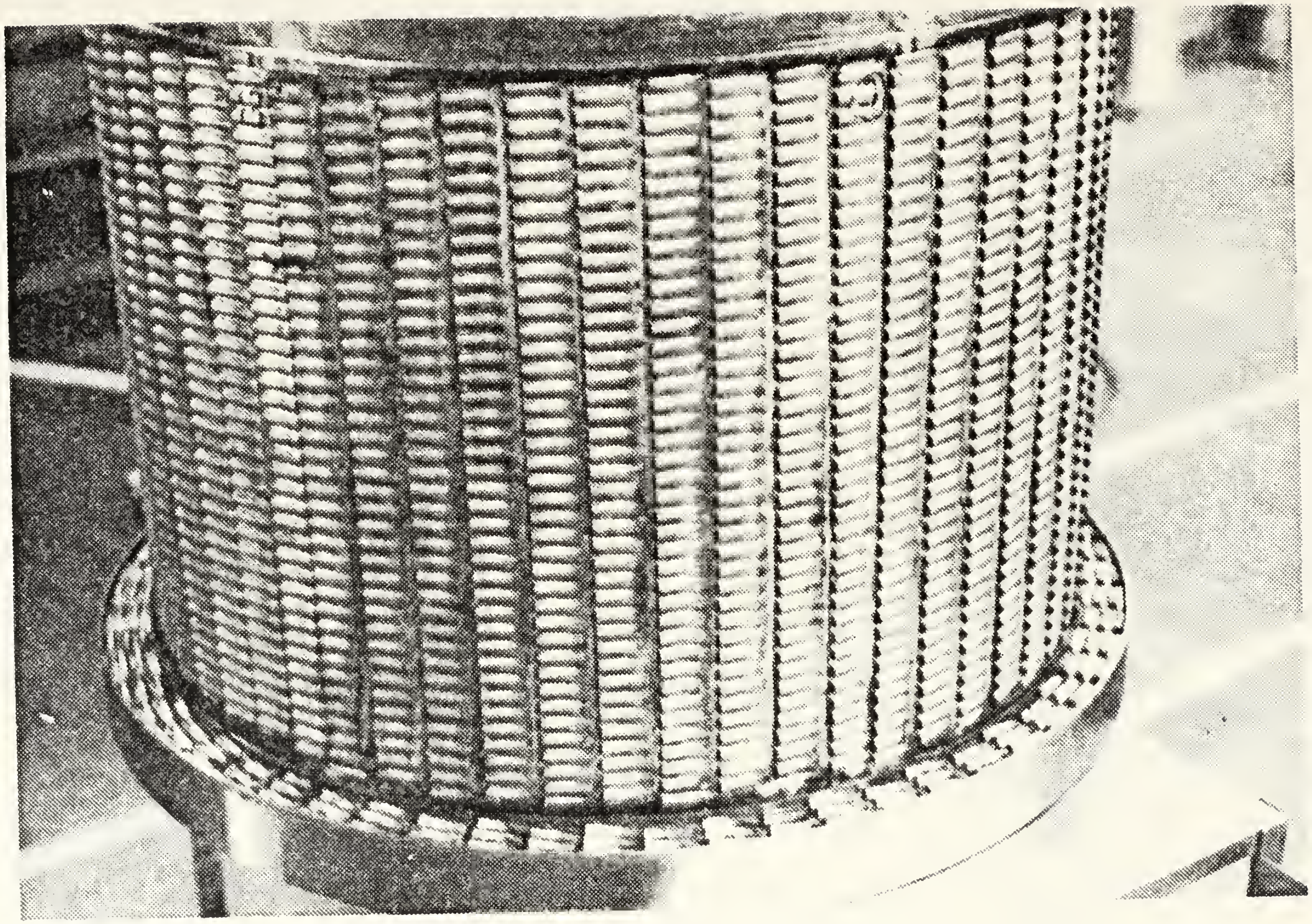


Figure 3. View of the Generating Cylinder and Jet Wall Hardware

| SHROUD | | | HUB | | |
|---|---|---|---|---|---|
| POINT | Z (FT) | R (FT) | POINT | Z (FT) | R (FT) |
| 1 | .5 | 1.75 | 1 | .5 | 1.41667 |
| 2 | .75 | 1.75 | 2 | .75 | 1.41667 |
| 3 | 1.0 | 1.75 | 3 | 1.0 | 1.41667 |
| 4 | 1.25 | 1.75 | 4 | 1.25 | 1.41667 |
| 5 | 1.5 | 1.75 | 5 | 1.5 | 1.41667 |
| 6 | 1.75 | 1.75 | 6 | 1.75 | 1.41667 |
| 7 | 1.7917 | 1.7556 | 7 | 1.8587 | 1.41667 |
| 8 | 1.8333 | 1.7754 | 8 | 1.9421 | 1.439 |
| 9 | 1.875 | 1.8225 | 9 | 2.0031 | 1.5 |
| 10 | 1.8917 | 1.8538 | 10 | 2.0254 | 1.5833 |
| 11 | 1.9042 | 1.8875 | 11 | 2.0254 | 1.75 |
| 12 | 1.9083 | 1.90625 | 12 | 2.0254 | 2. |
| 13 | 1.9167 | 2.0 | 13 | 2.0254 | 2.4746 |
| 14 | 1.9167 | 2.25 | | | |
| 15 | 1.9167 | 2.5 | | | |

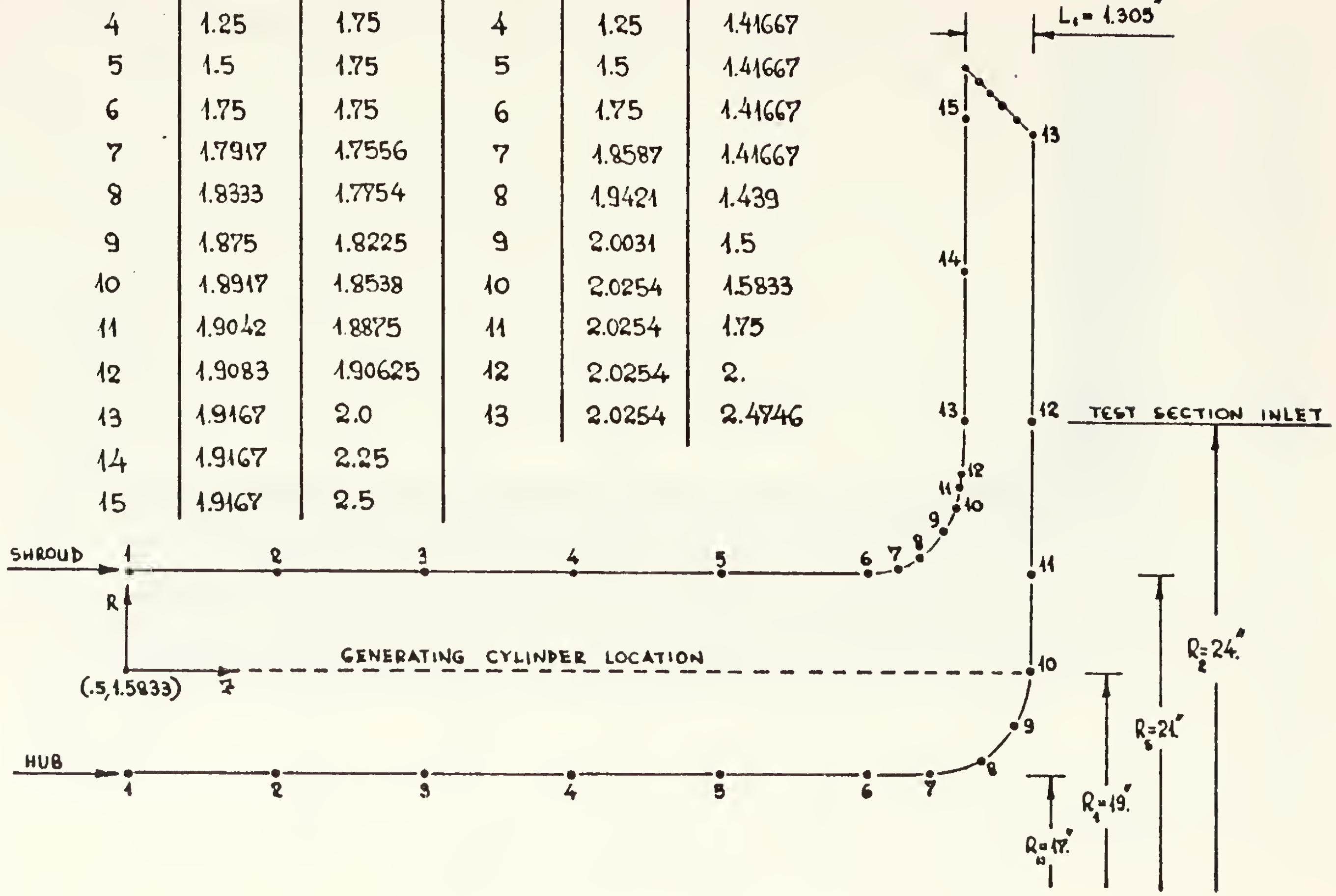
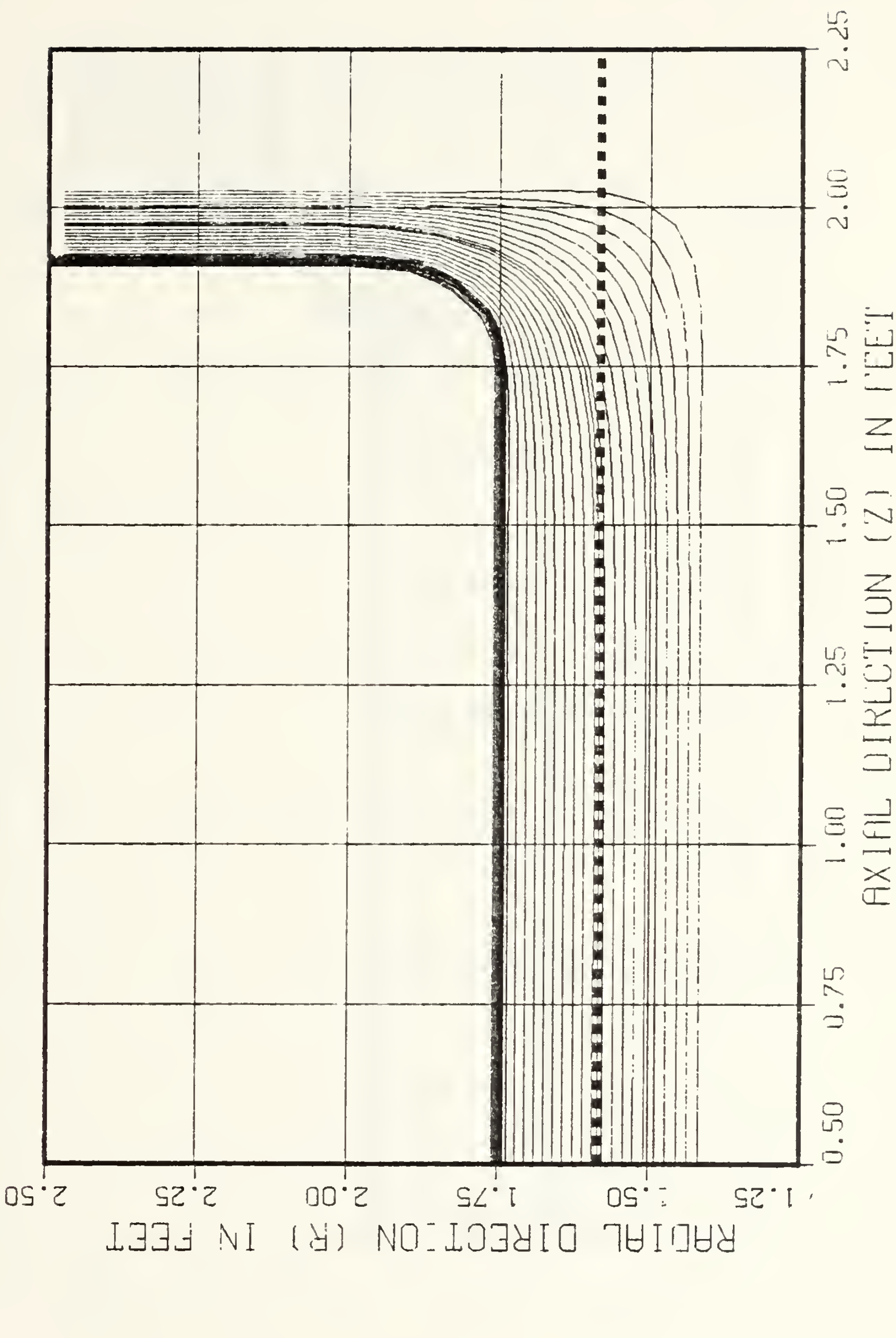



Figure 4. CDTD Flowfield Model for MERIDL

FIGURE 5a

STREAMLINES GENERATED BY MERIDL



# FIGURE 5b

STREAMLINES IN CONTRACTION CONE

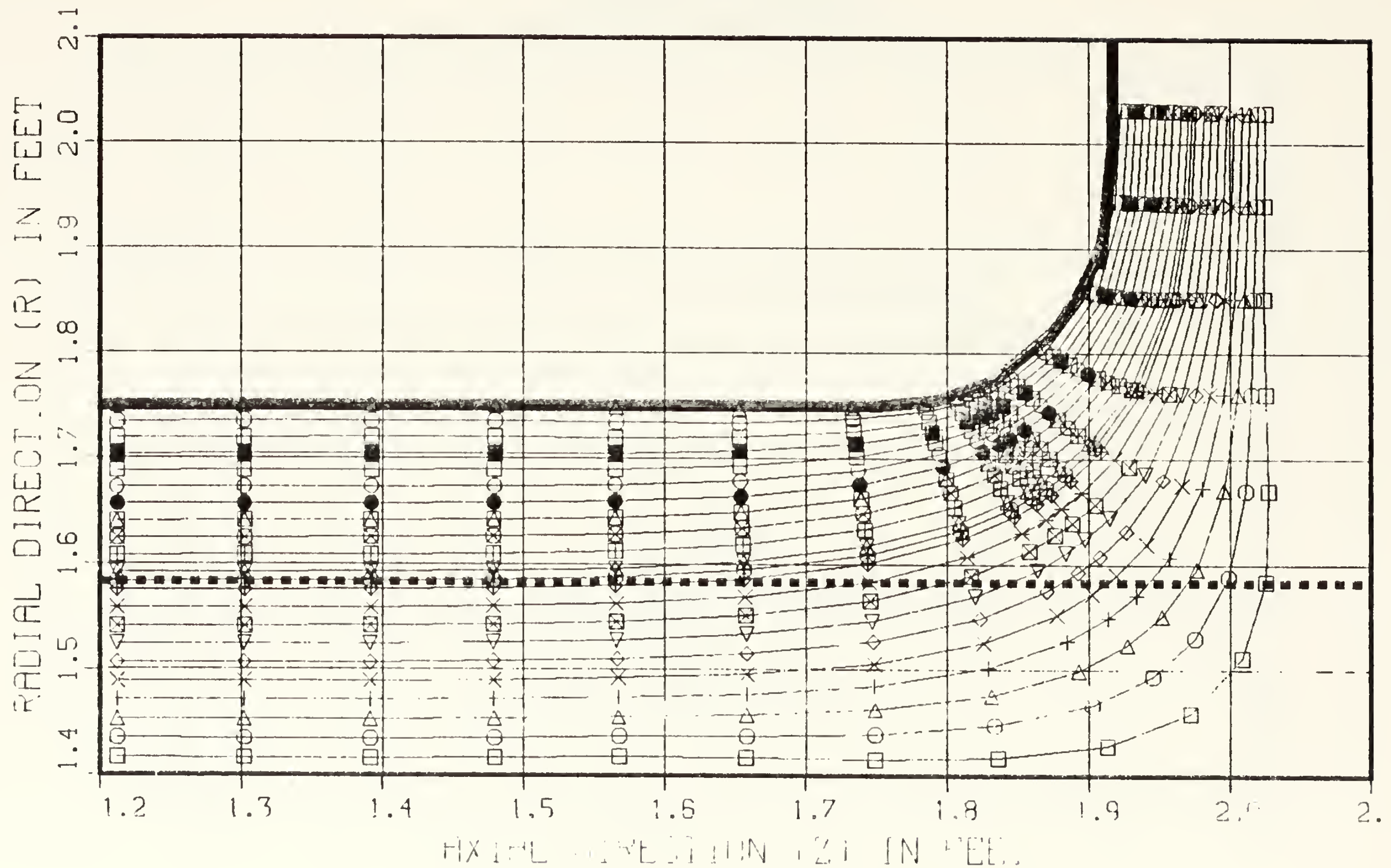


FIGURE 6

TOTAL VELOCITY VARIATION

ALONG CONTRACTION CONTOUR (STATIONS 14-24)

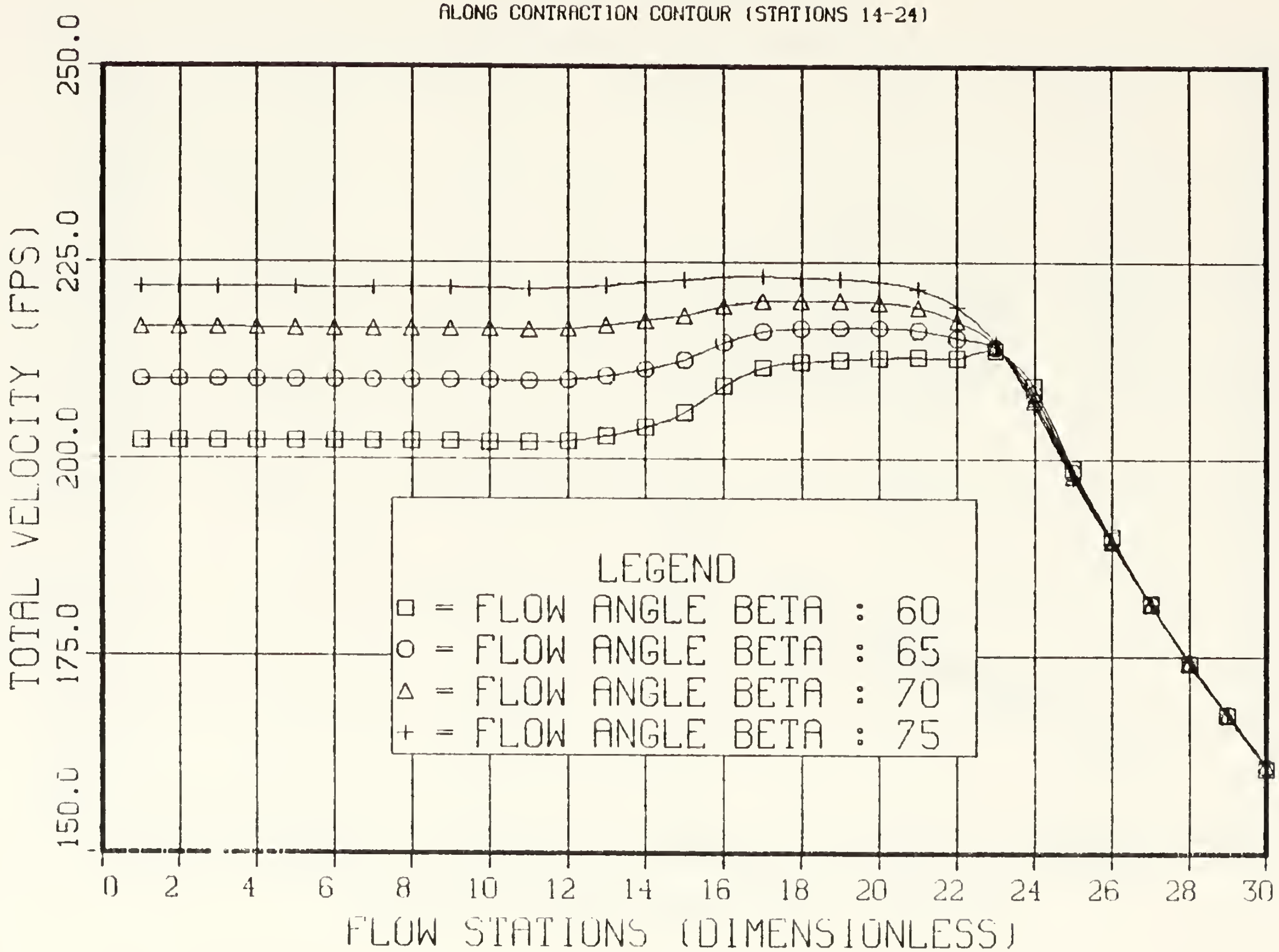


FIGURE 7

TOTAL VELOCITY VARIATION
ALONG - 0.0 (STATIONS 19-25)

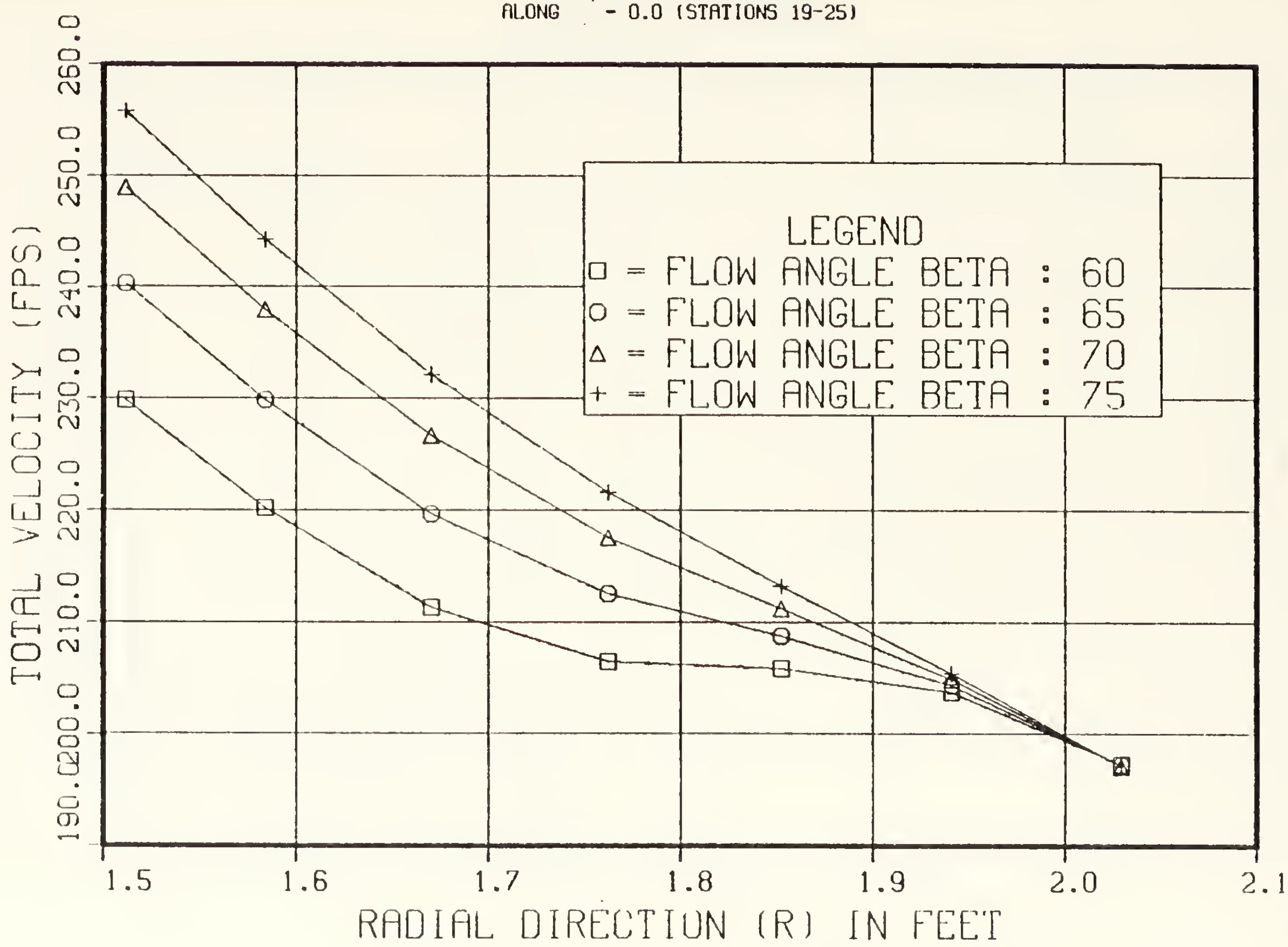
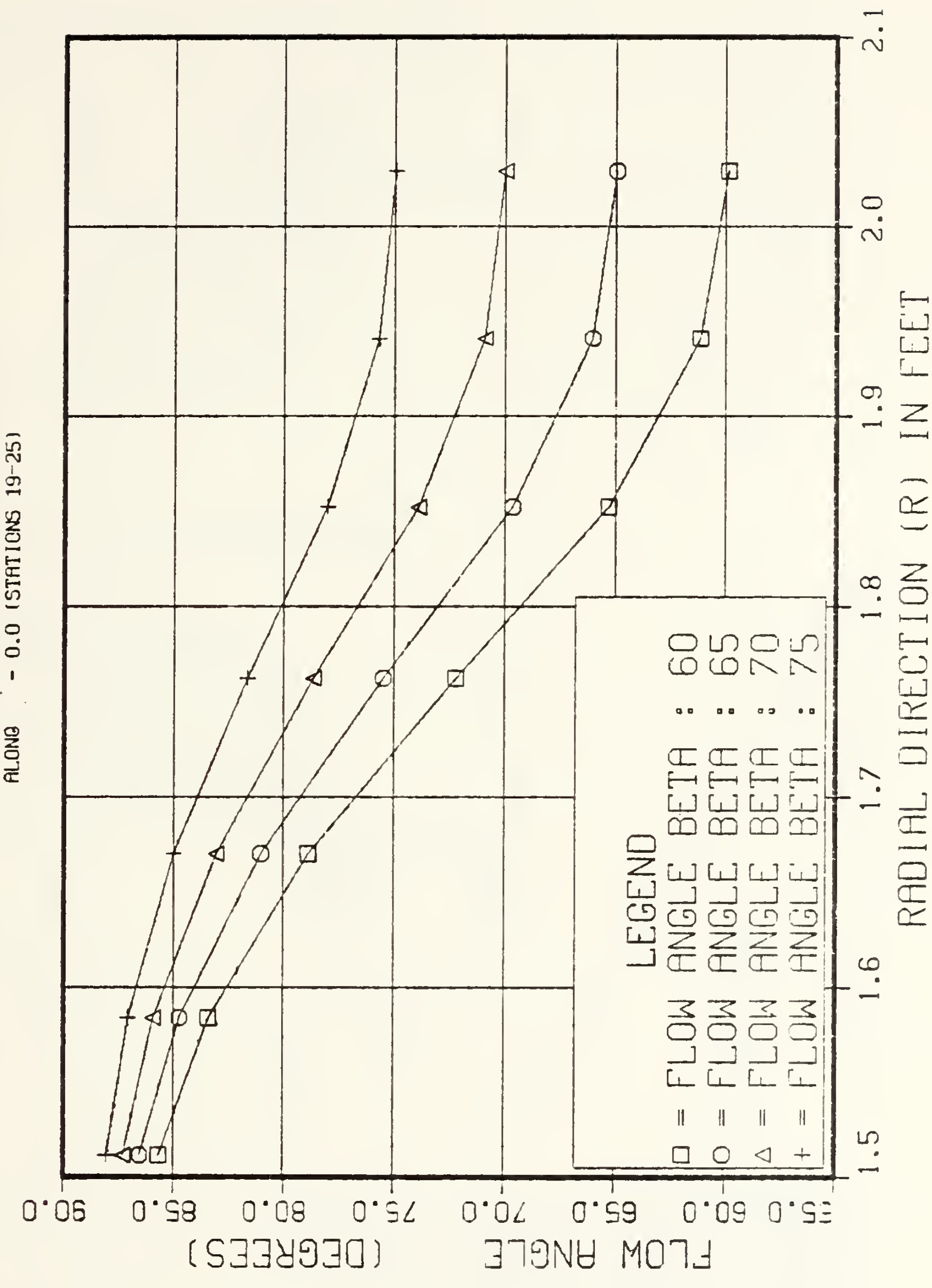


FIGURE 8

FLOW ANGLE VARIATION

ALONG - 0.0 (STATIONS 19-25)



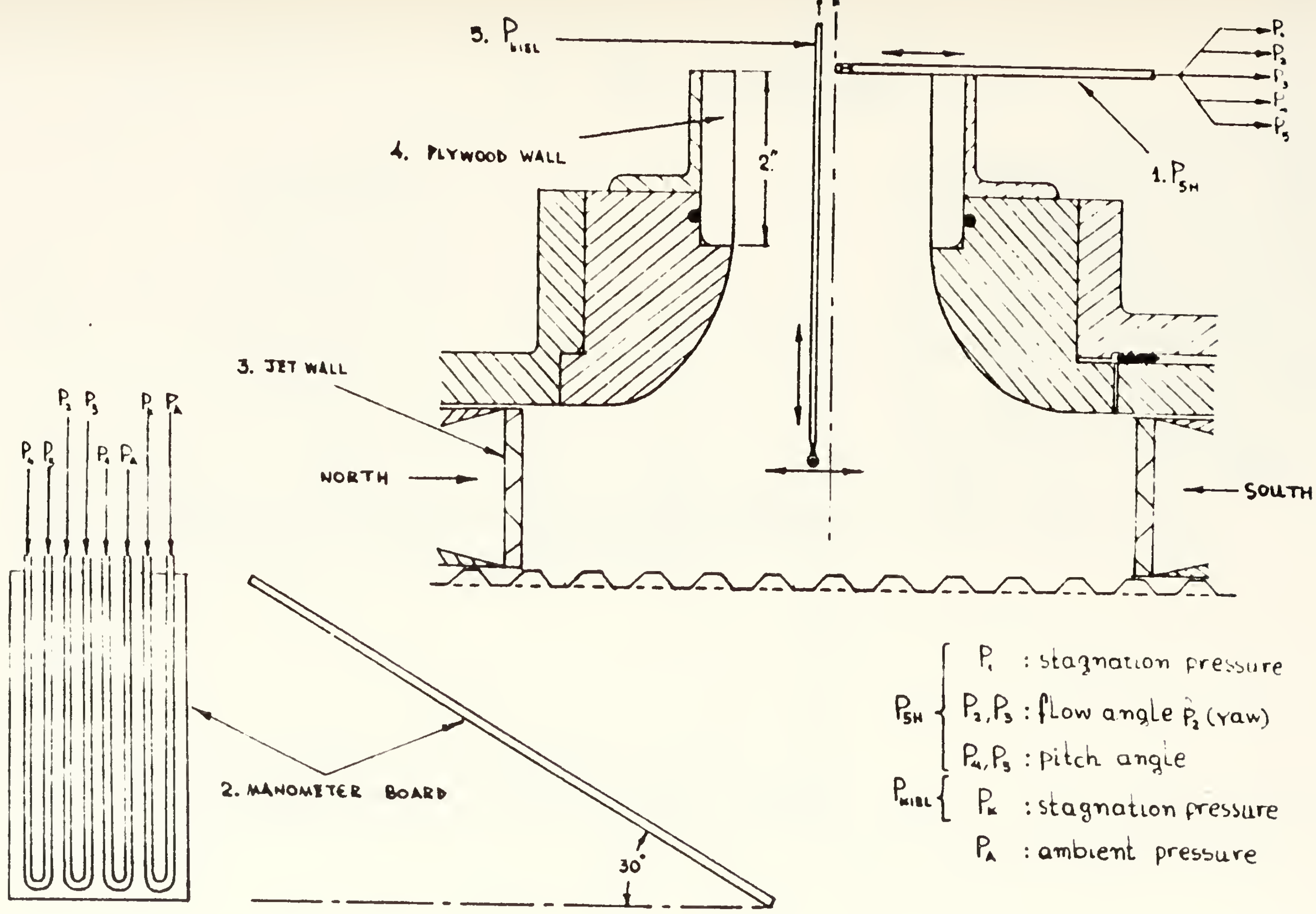



Figure 9. Installed Instrumentation for Preliminary Measurements

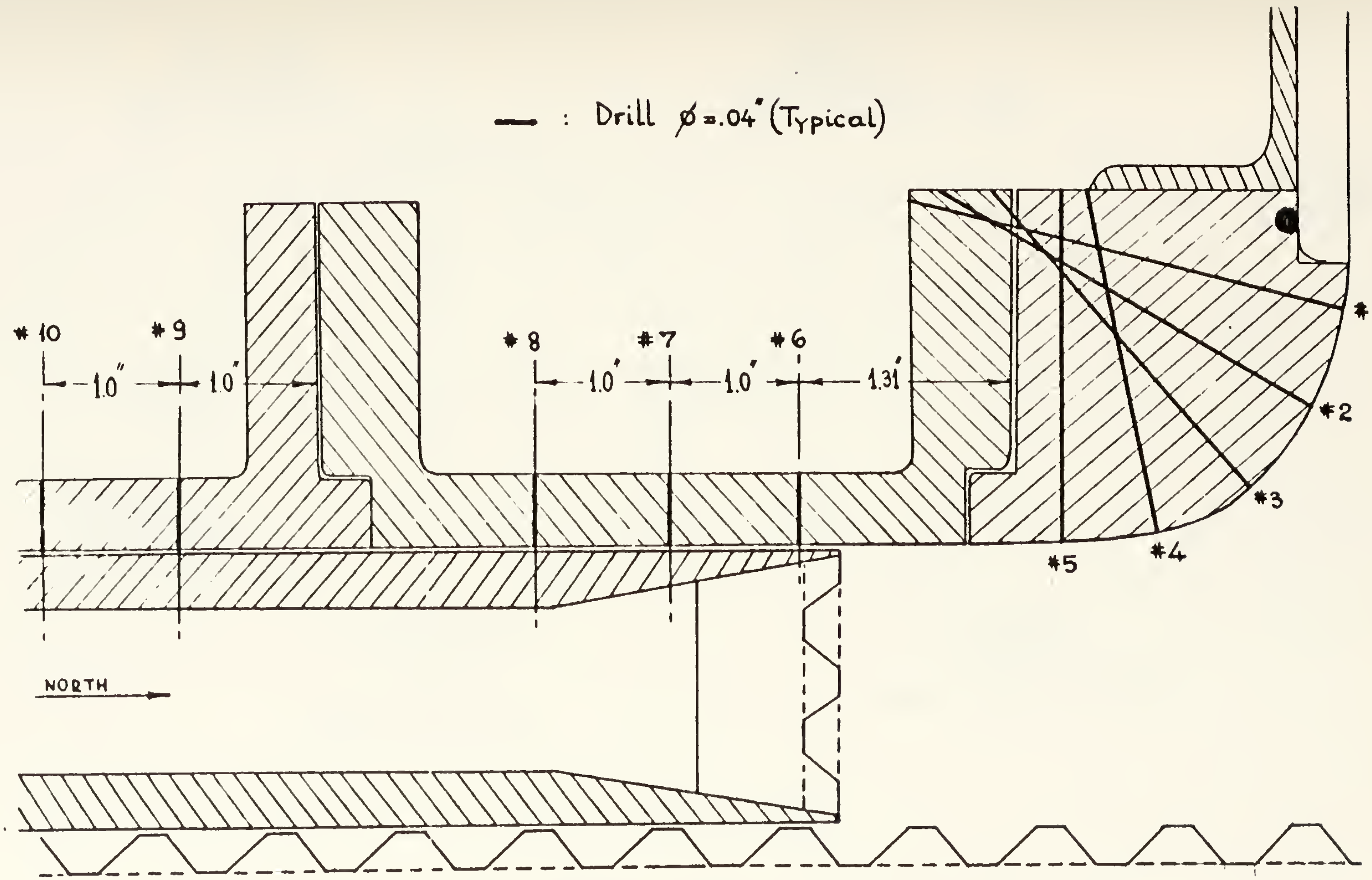



Figure 10a. Instrumentation Not Installed for Preliminary Measurements

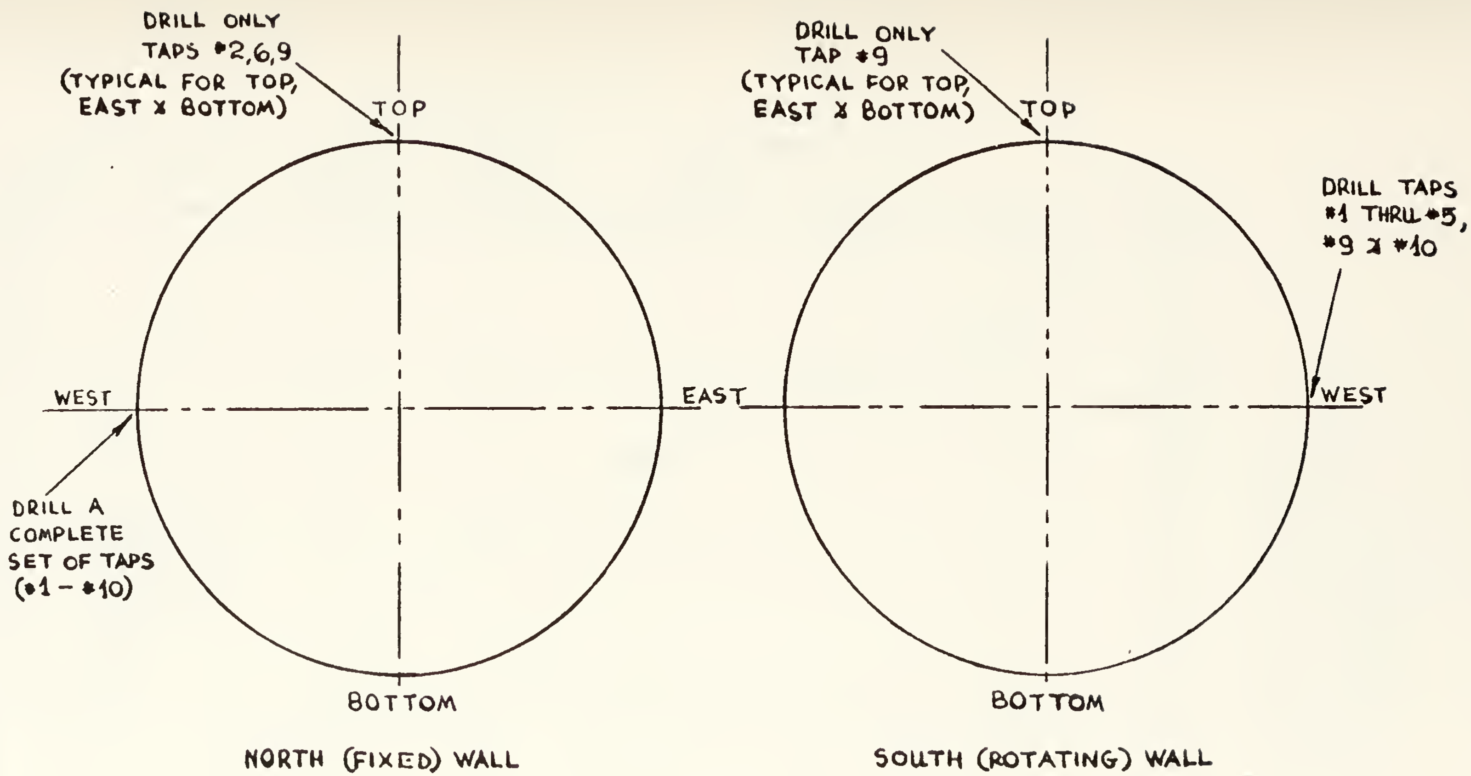



Figure 10b. Circumferential Arrangement of Pressure Taps

FIGURE 11

JW SEALING EFFECT IN FLOW ANGLE (WEST)

JW SPACING : 8.0,THROTTLES : OPEN

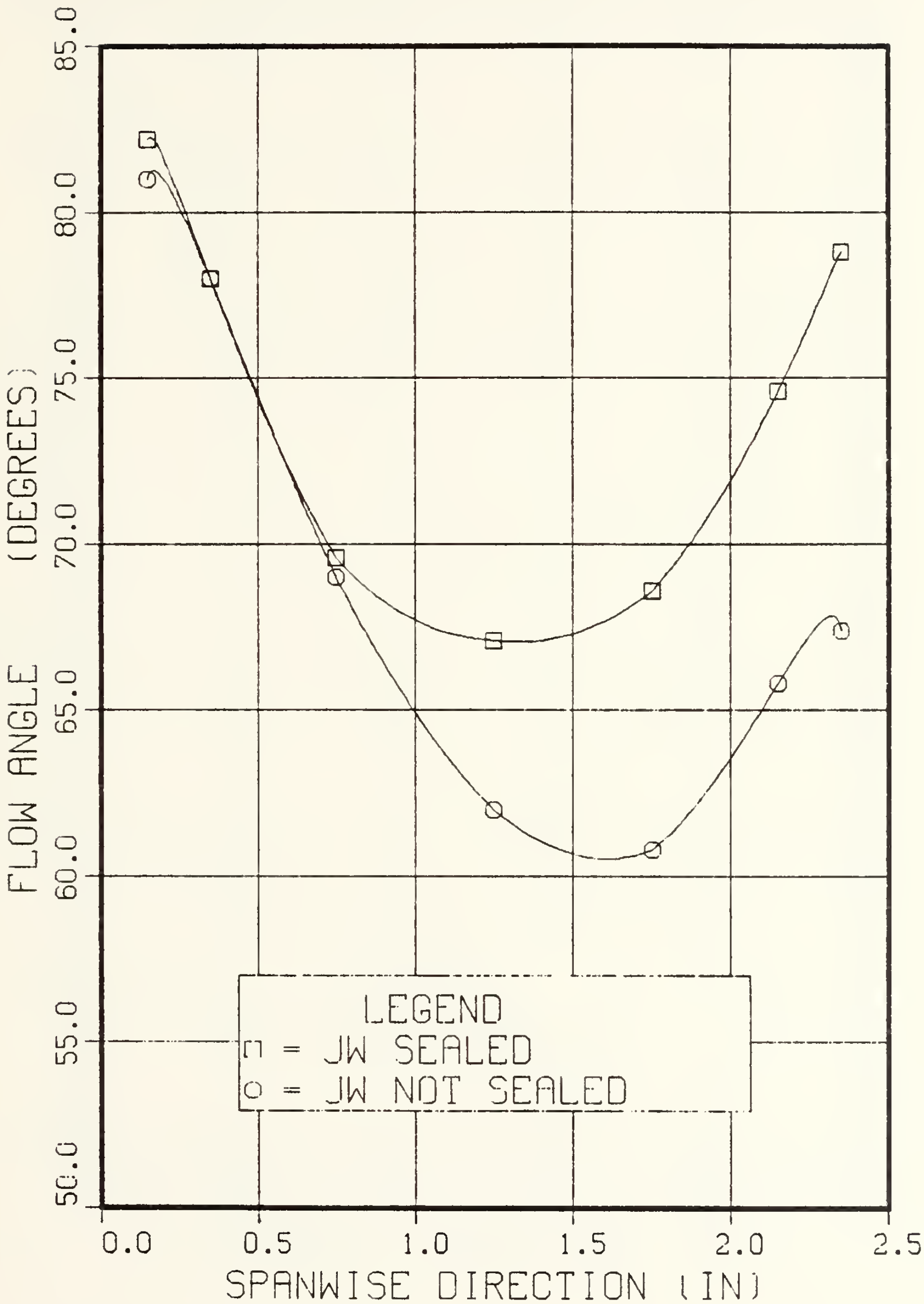


FIGURE 12

JW SEALING EFFECT IN FLOW ANGLE (WEST)

JW SPACING : 8.0,THROTTLES : CLOSED

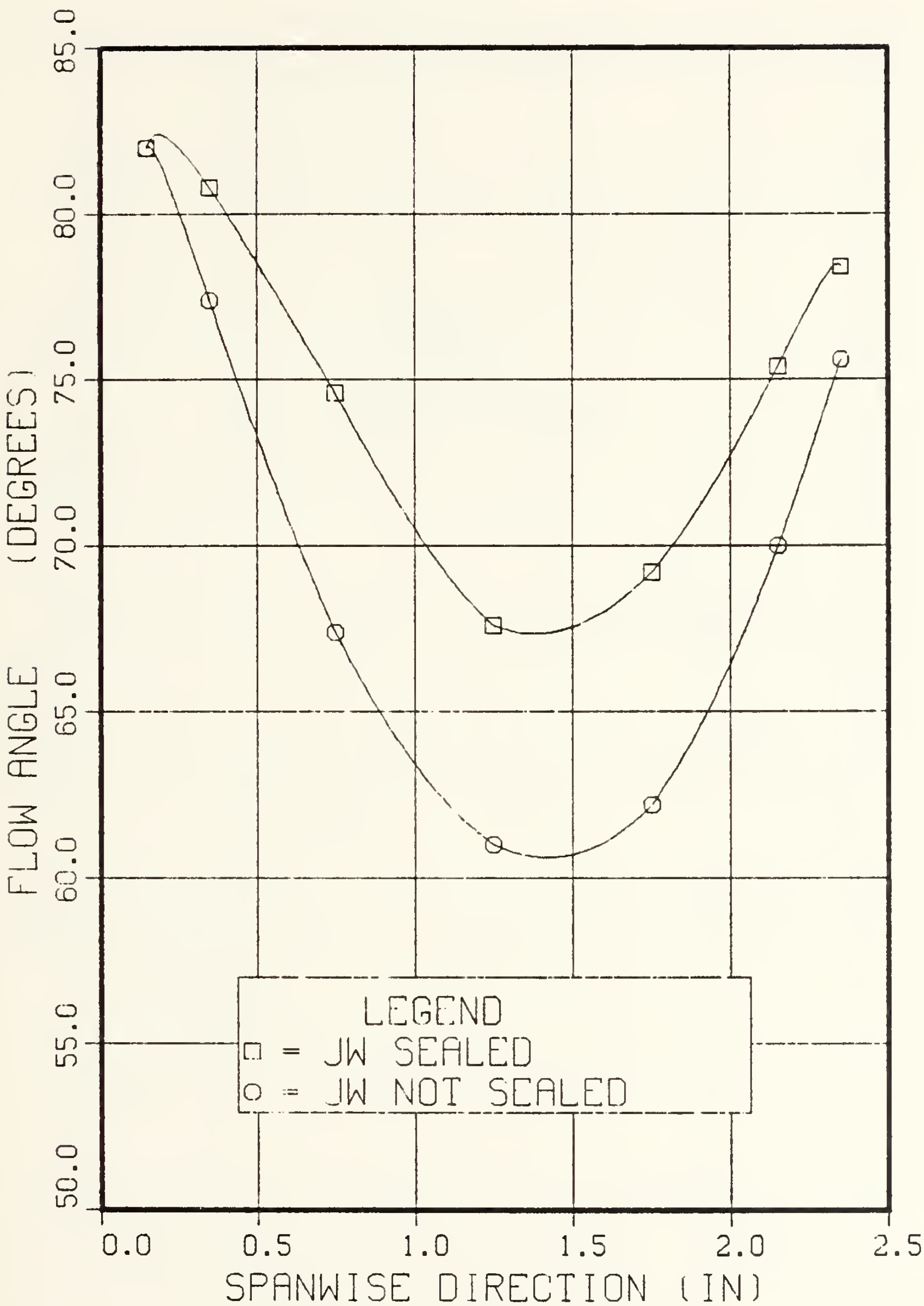


FIGURE 13

JW SEALING EFFECT IN TOTAL PRESSURE (WEST)

JW SPACING : 8.0,THROTTLES : OPEN

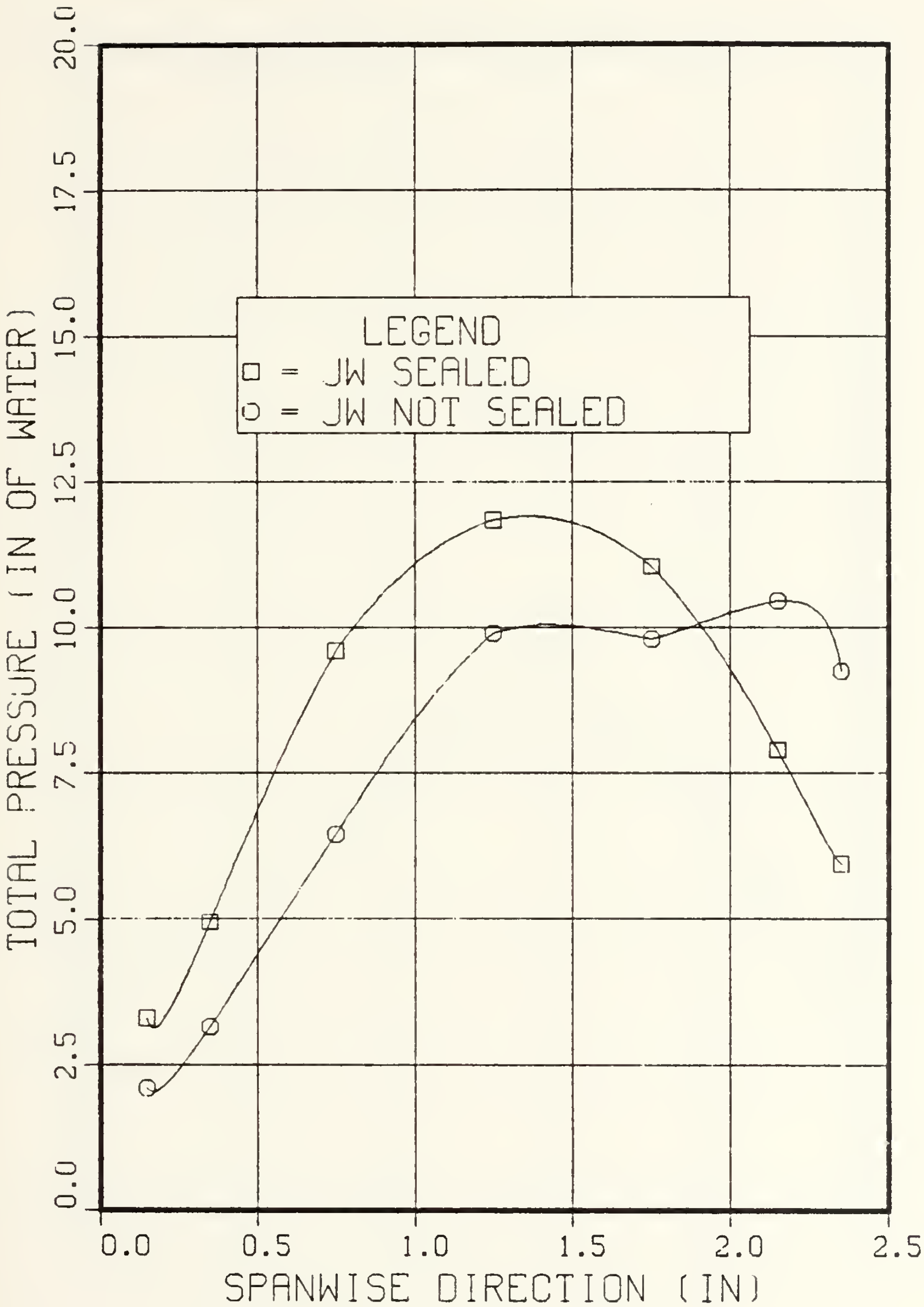


FIGURE 14

JW SEALING EFFECT IN TOTAL PRESSURE (WEST)

JW SPACING : 8.0,THROTTLES : CLOSED

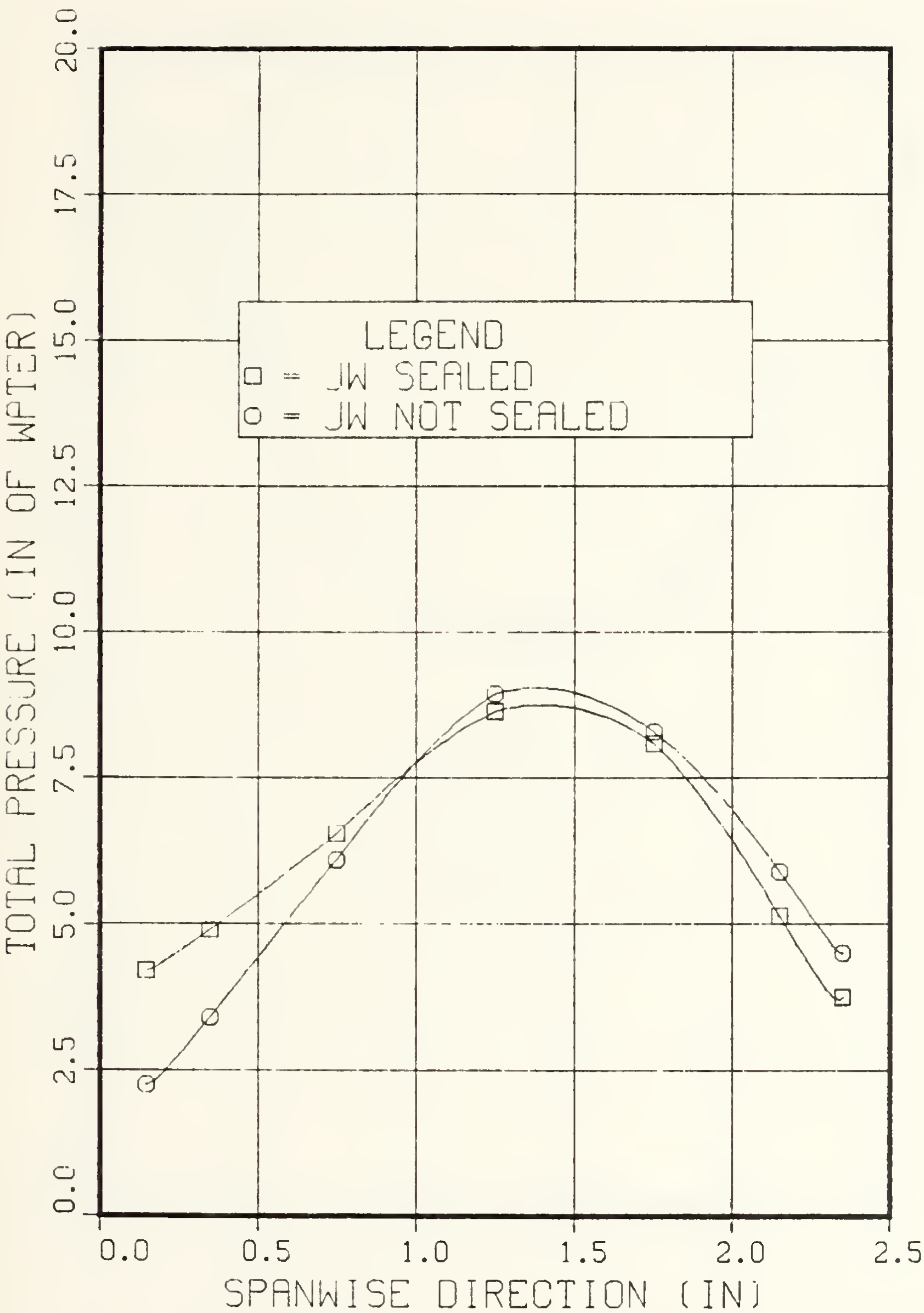


FIGURE 15

CIRCUMFERENTIAL MEASUREMENTS (FLOW ANGLE)

JW SPACING : [illegible].0 IN, THROTTLES : OPEN

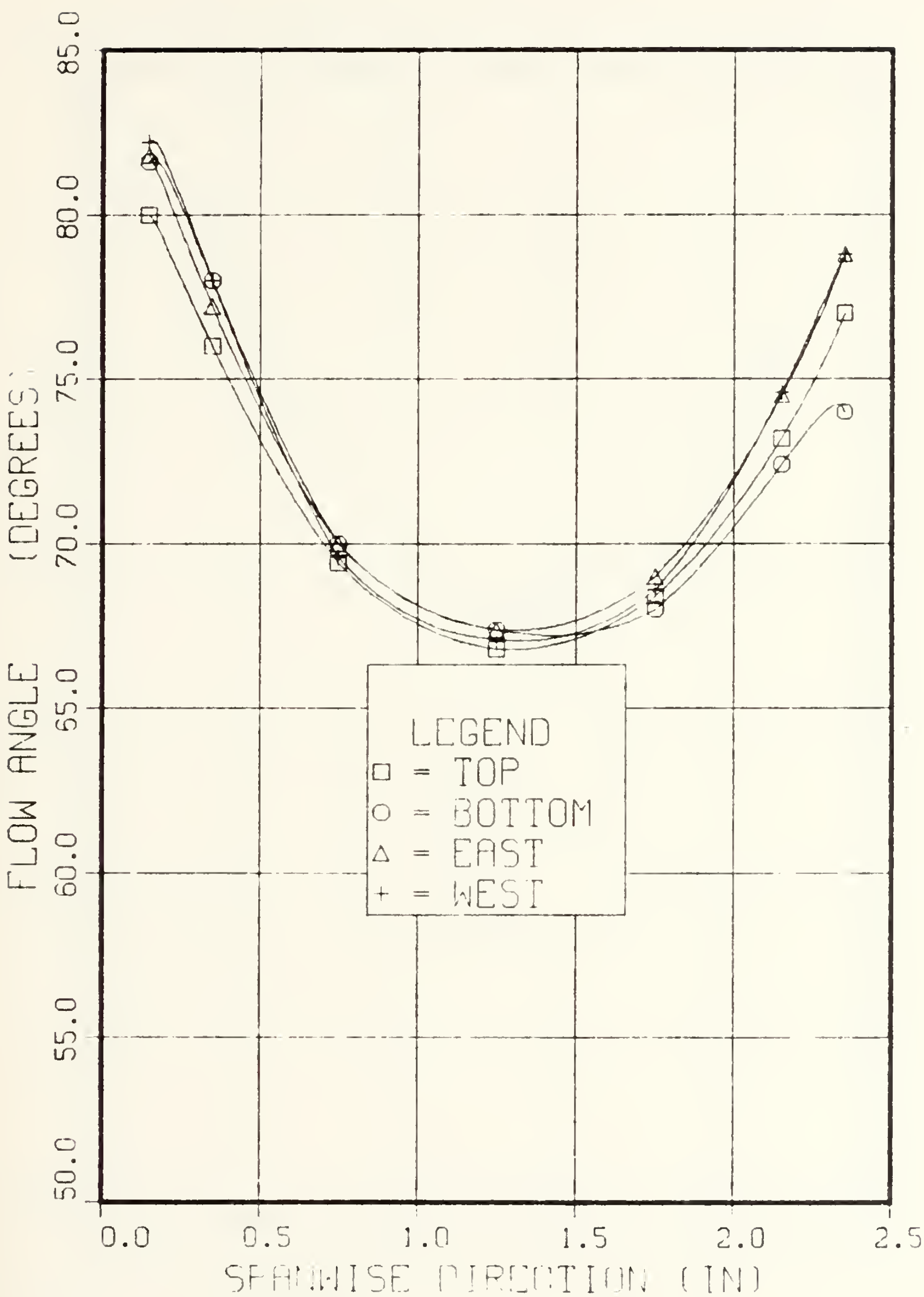


FIGURE 16

CIRCUMFERENTIAL MEASUREMENTS (FLOW ANGLE)

[illegible]W SPACING : 8.[illegible] IN, THROTTLES : CLOSED

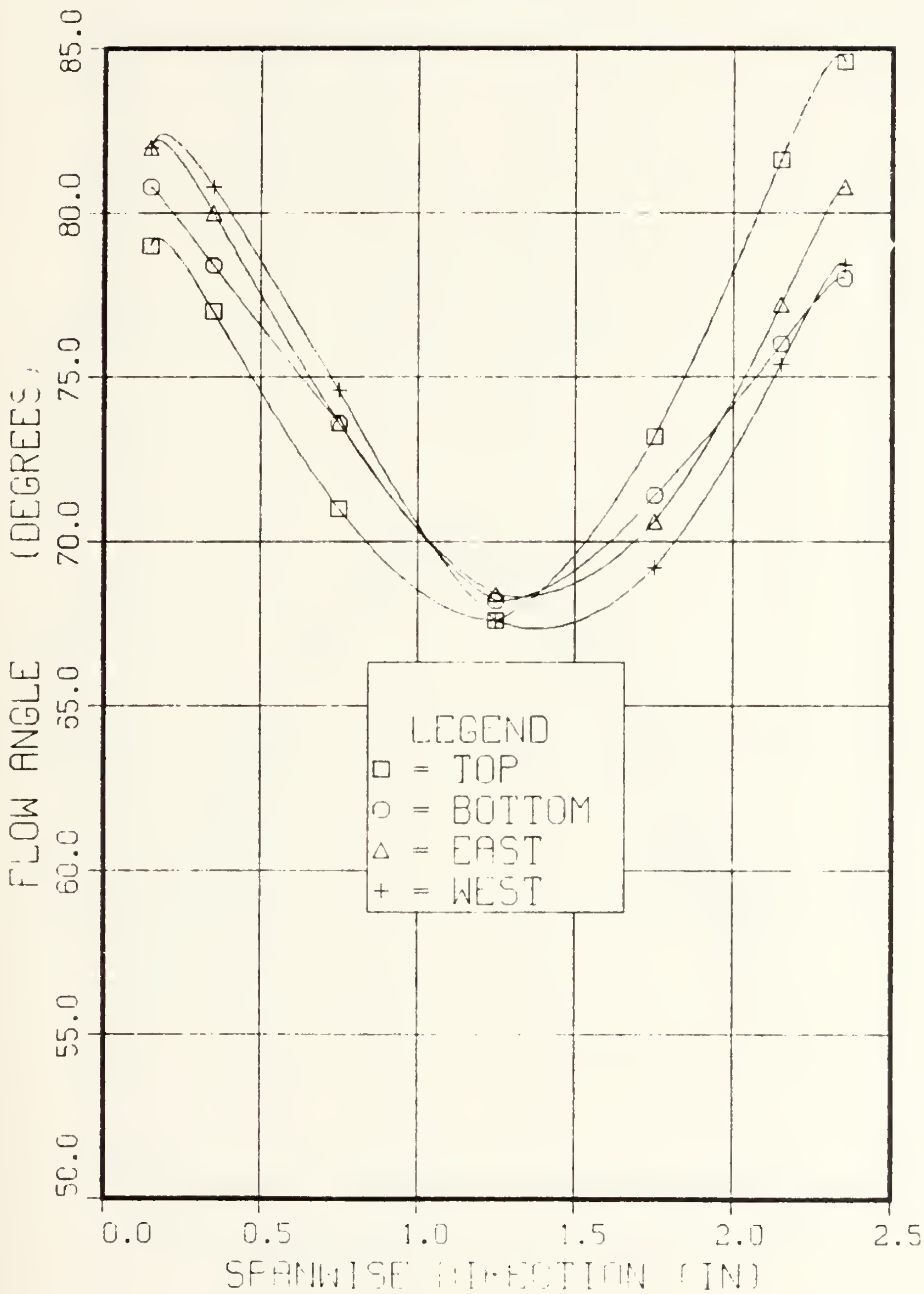


FIGURE 17

CIRCUMFERENTIAL MEASUREMENTS (PRESSURE)

JW SPACING : [illegible] IN ,THROTTLES : OPEN

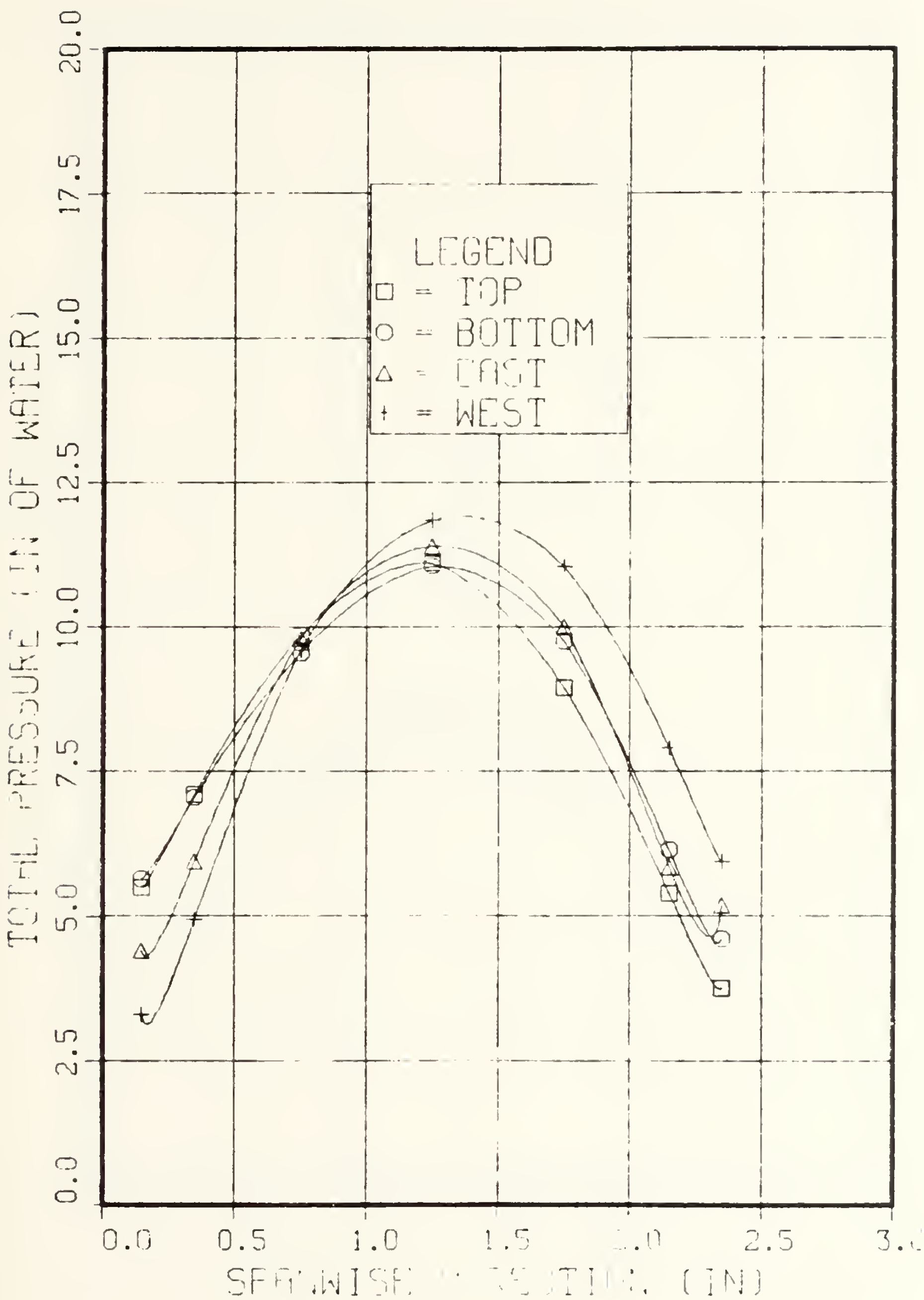


FIGURE 18

CIRCUMFERENTIAL MEASUREMENTS (PRESSURE)

JW SPACING : 6.0 IN ,THROTTLES : CLOSED

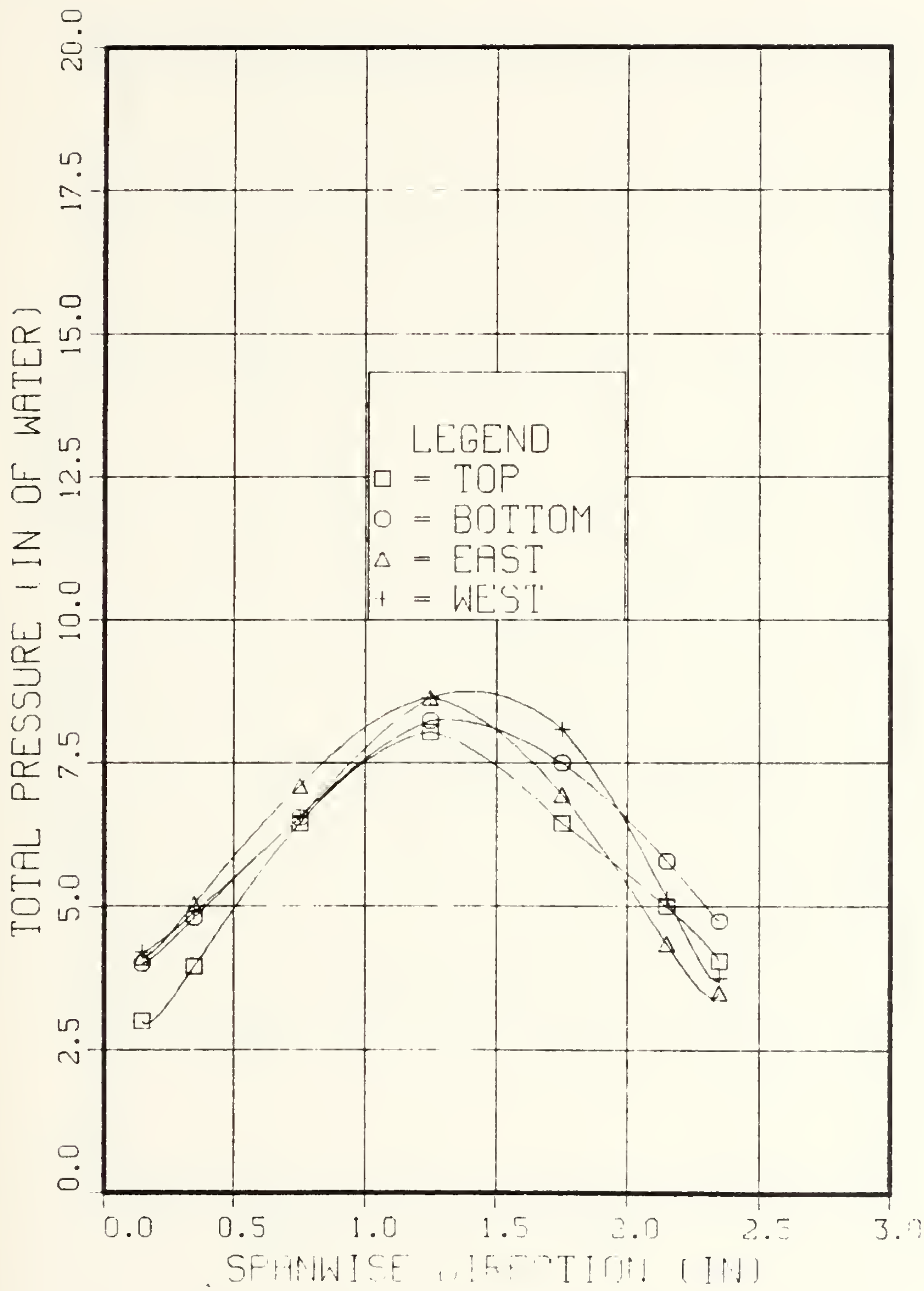


FIGURE 19

JW SPACING EFFECT IN FLOW ANGLE (WEST)

THROTTLES : OPEN

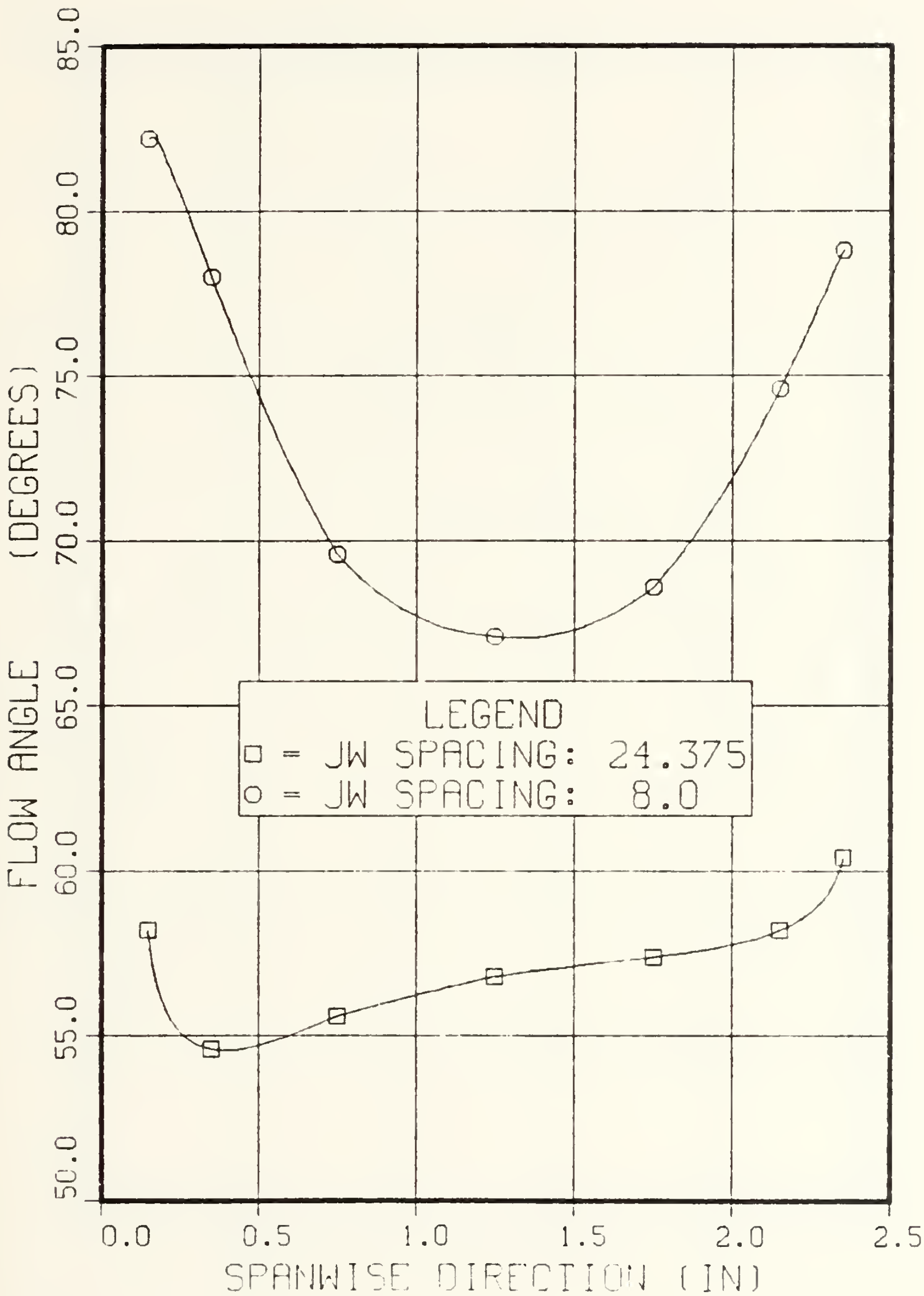


FIGURE 20

JW SPACING EFFECT ON TOTAL PRESSURE (WEST)

THROTTLES : OPEN

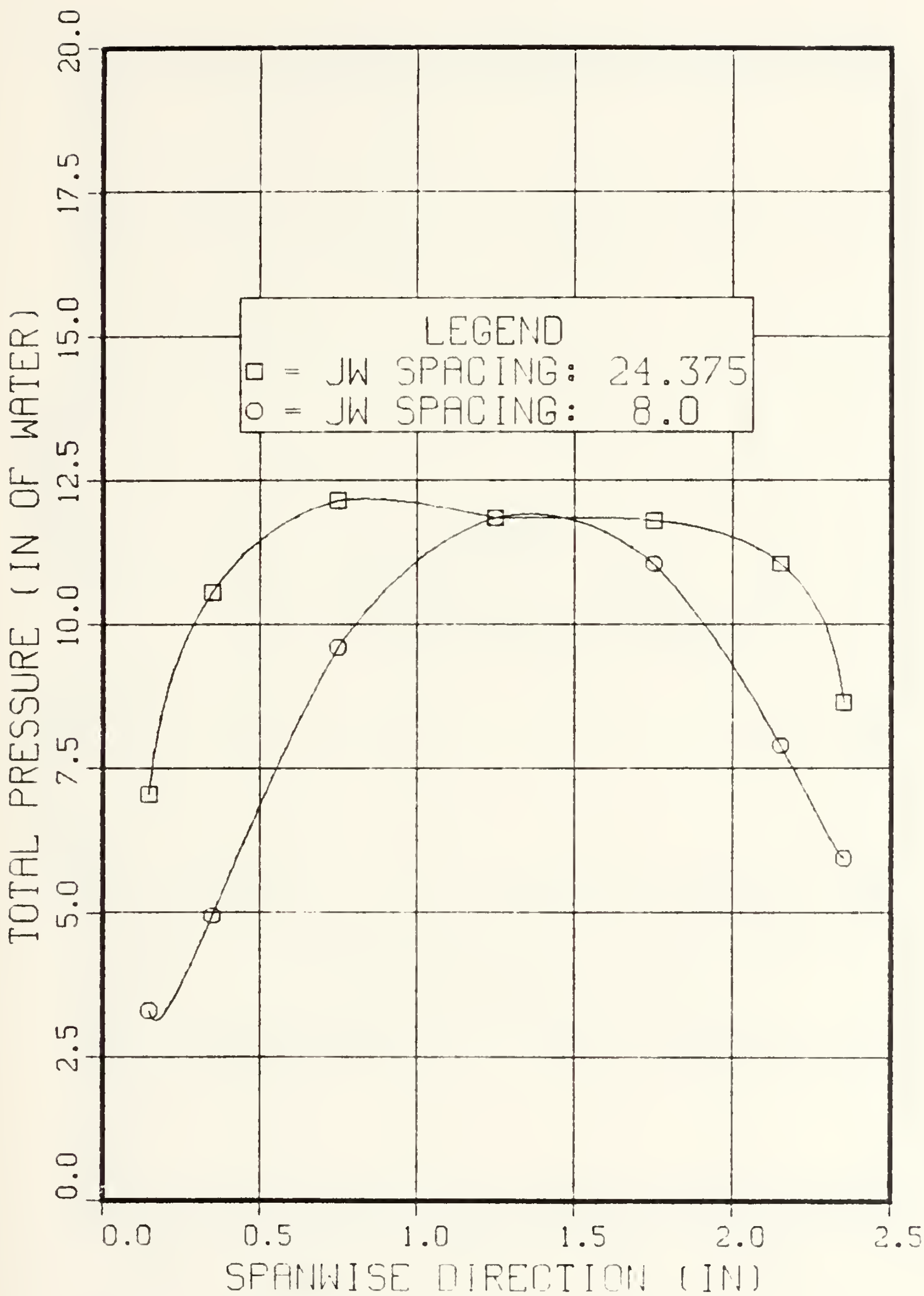


FIGURE 21

THROTTLING EFFECT IN FLOW ANGLE (WEST)

JW SPACING : 24.375 IN

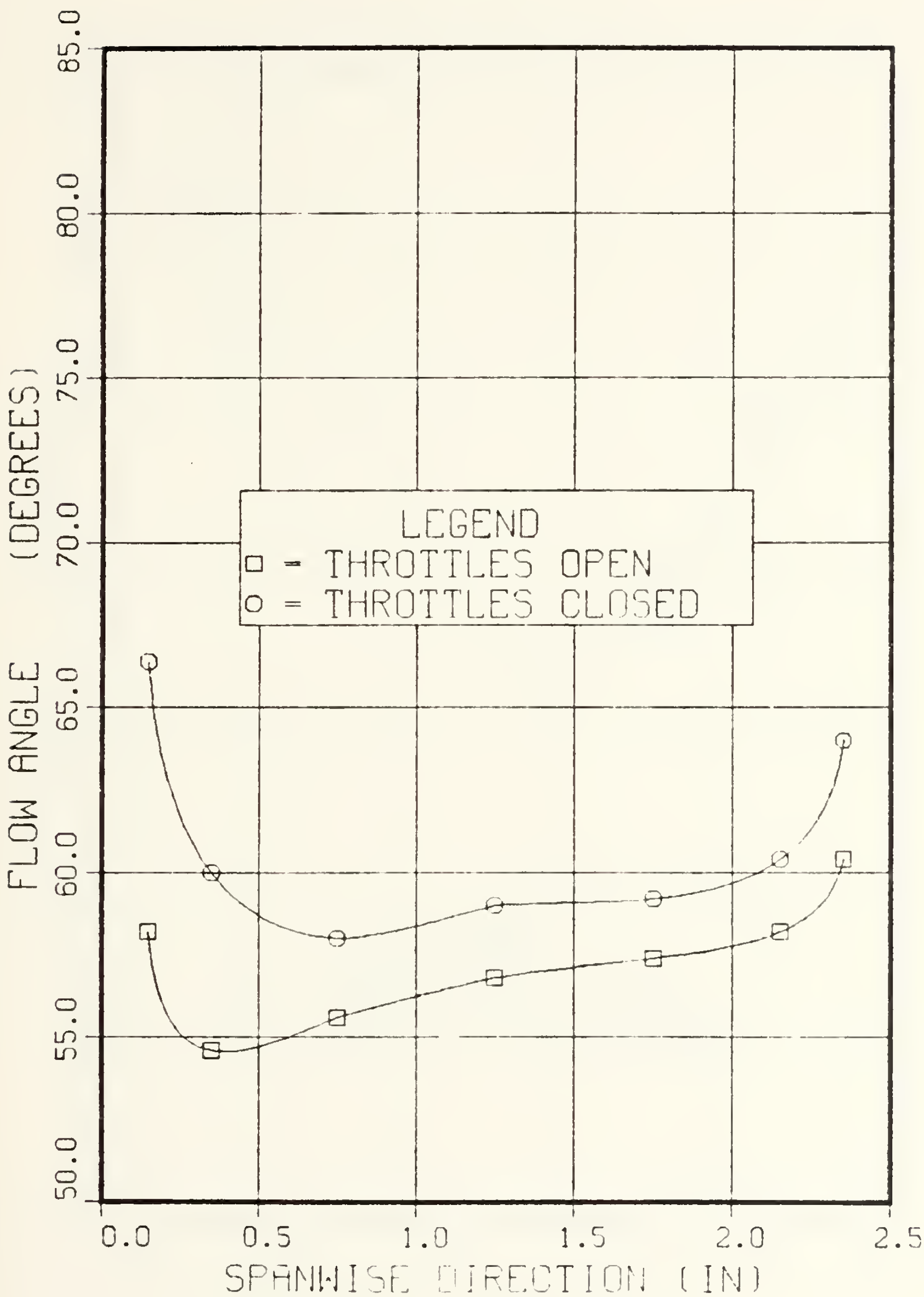


FIGURE 22

THROTTLING EFFECT IN FLOW ANGLE (WEST)

JW SPACING : 8.0 IN

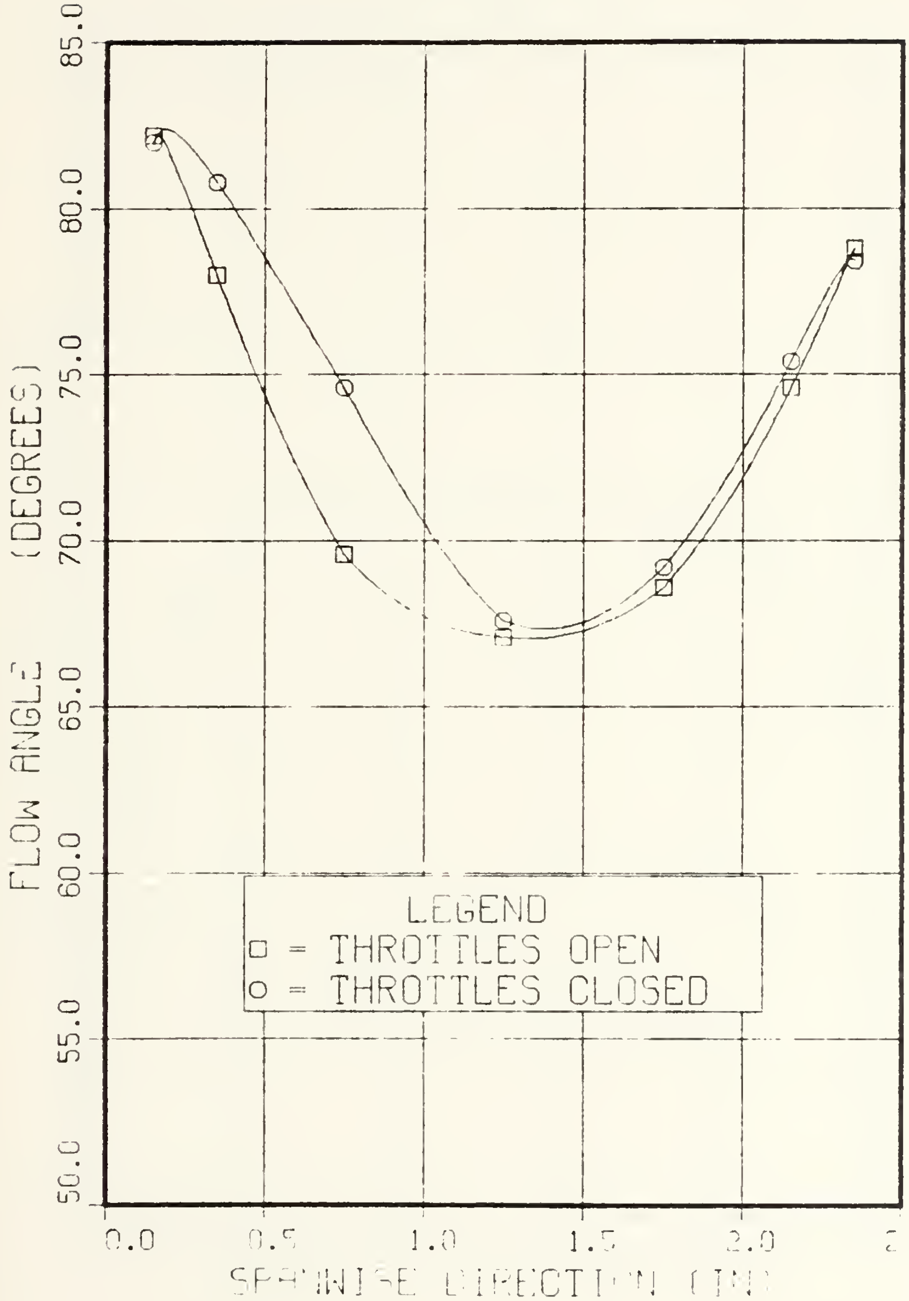


FIGURE 23

THROTTLING EFFECT IN TOTAL PRESSURE (WEST)

JW SPACING : 24.375 IN

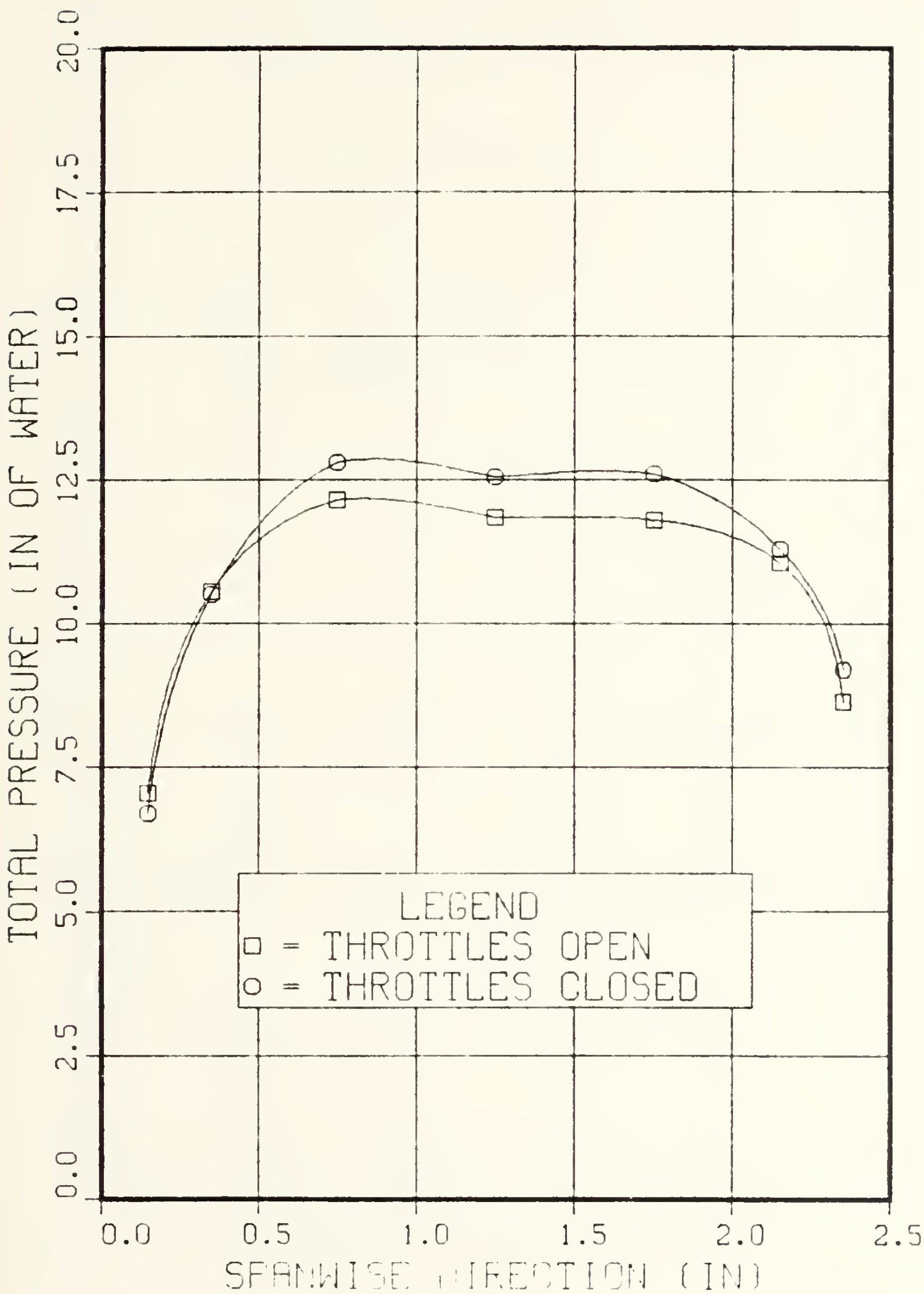


FIGURE 24

THROTTLING EFFECT ON TOTAL PRESSURE (WEST)

IN SPACING : 8.0 IN

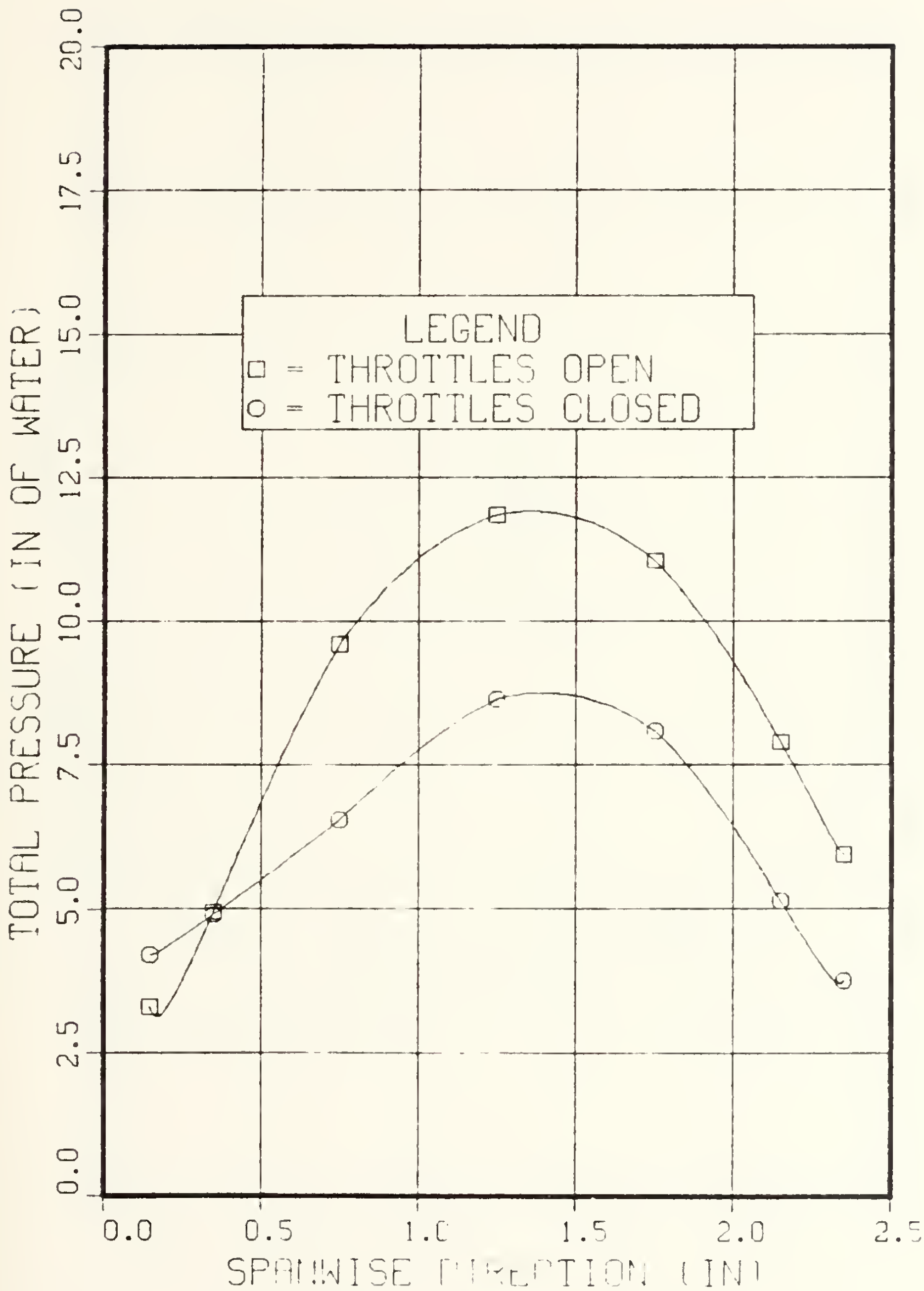


FIGURE 25

CIRCUMFERENTIAL MEASUREMENTS OF FLOW ANGLE

IW SPACING : 34.375 IN ,THROTTLED : OPEN

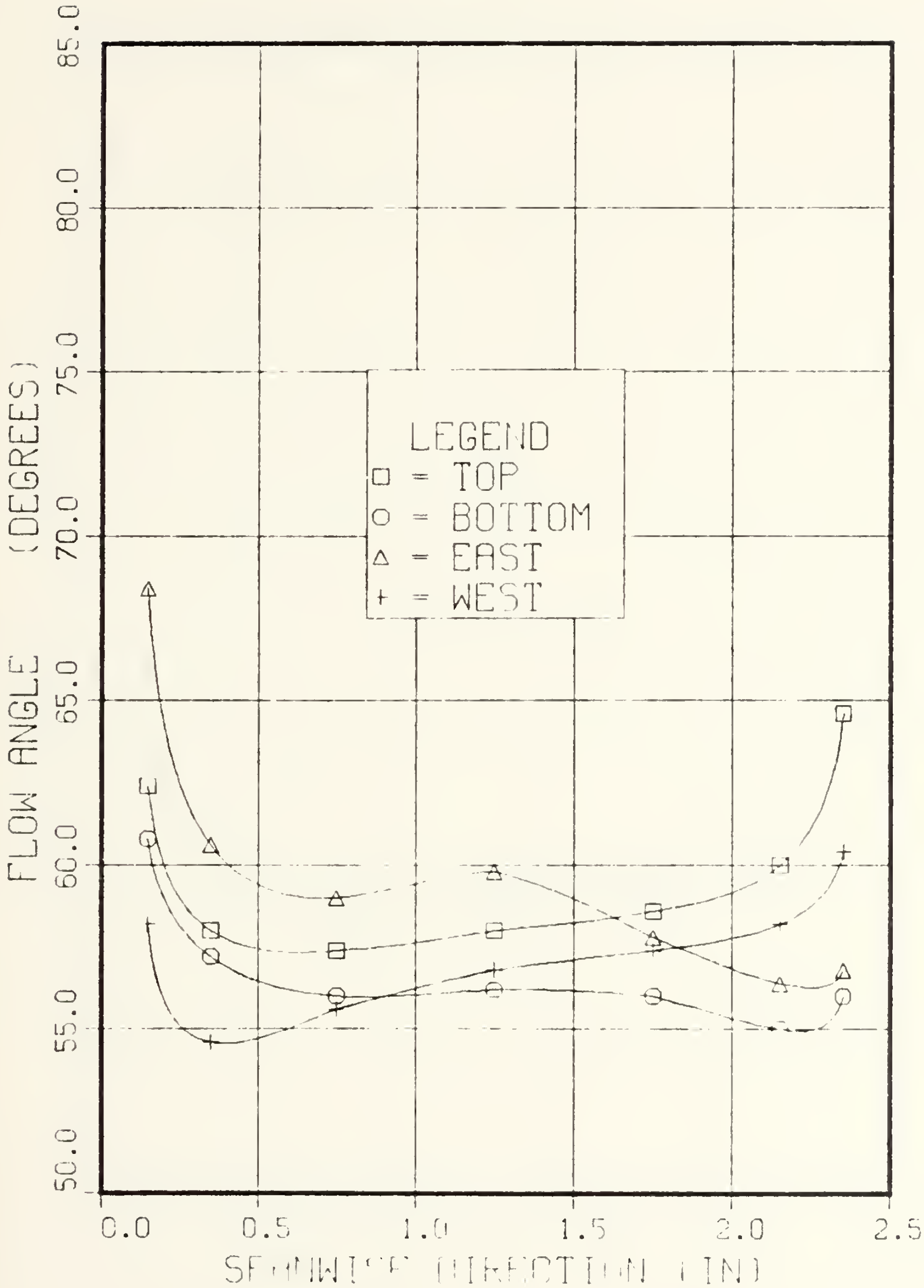


FIGURE 26

CIRCUMFERENTIAL MEASUREMENTS (FLOW ANGLE)

JW SPACING : 24.375 IN, THROTTLES : CLOSED

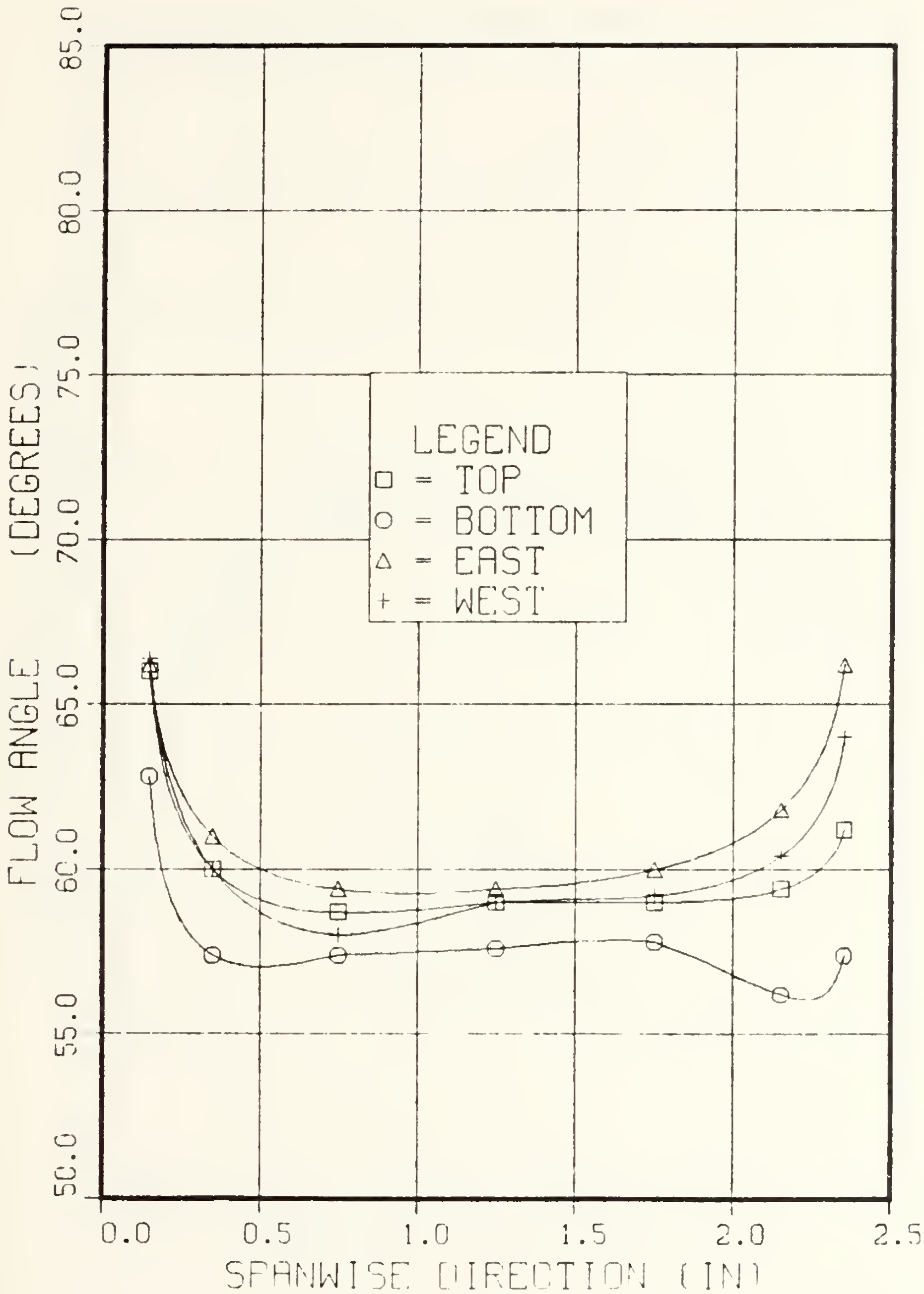


FIGURE 27

CIRCUMFERENTIAL MEASUREMENTS (PRESSURE)

JW SPACING : 24.375 IN ,THROTTLES : OPEN

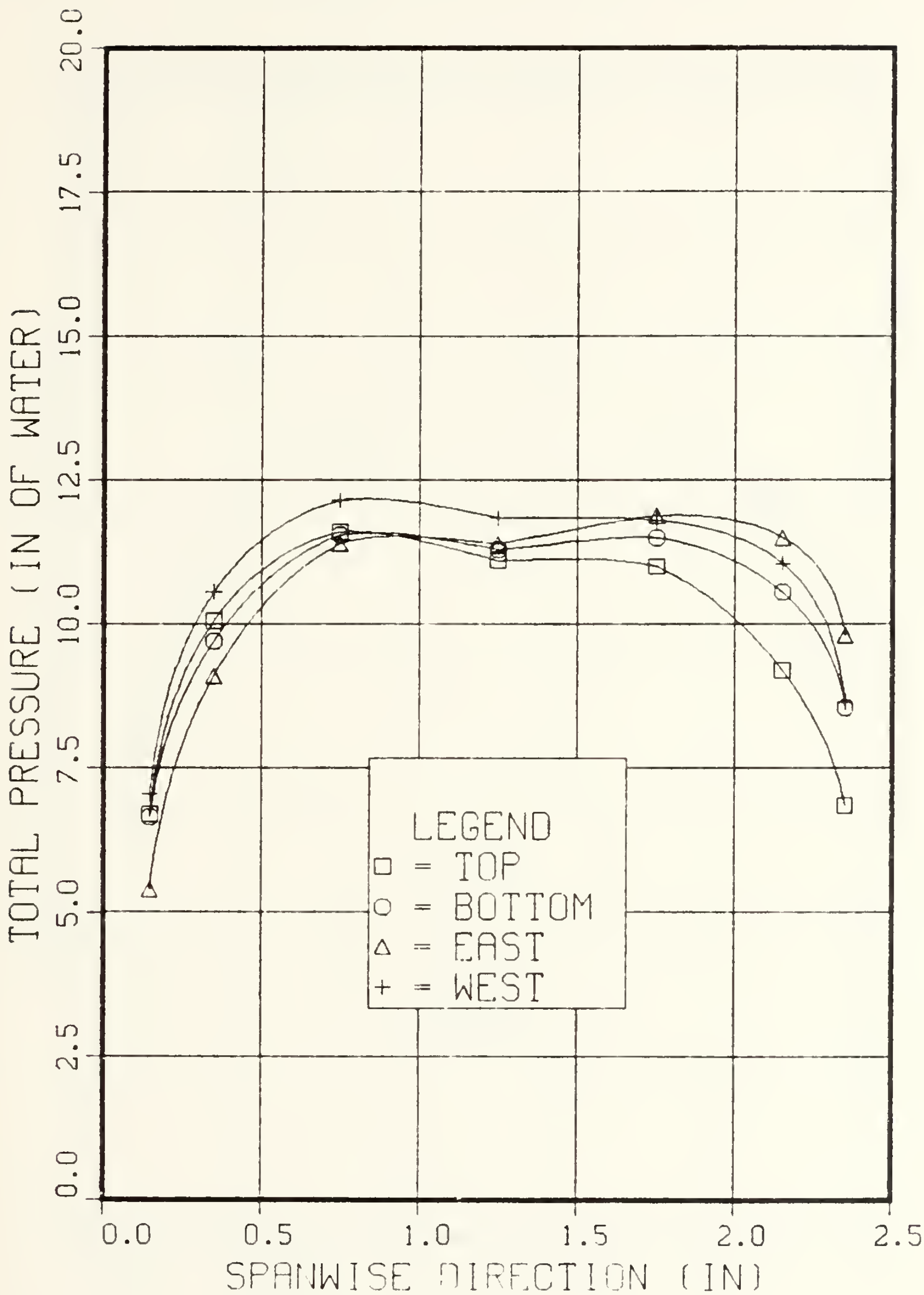


FIGURE 28

CIRCUMFERENTIAL MEASUREMENTS (PRESSURE)

JW SPACING : 24.375 IN ,THROTTLED : CLOSED

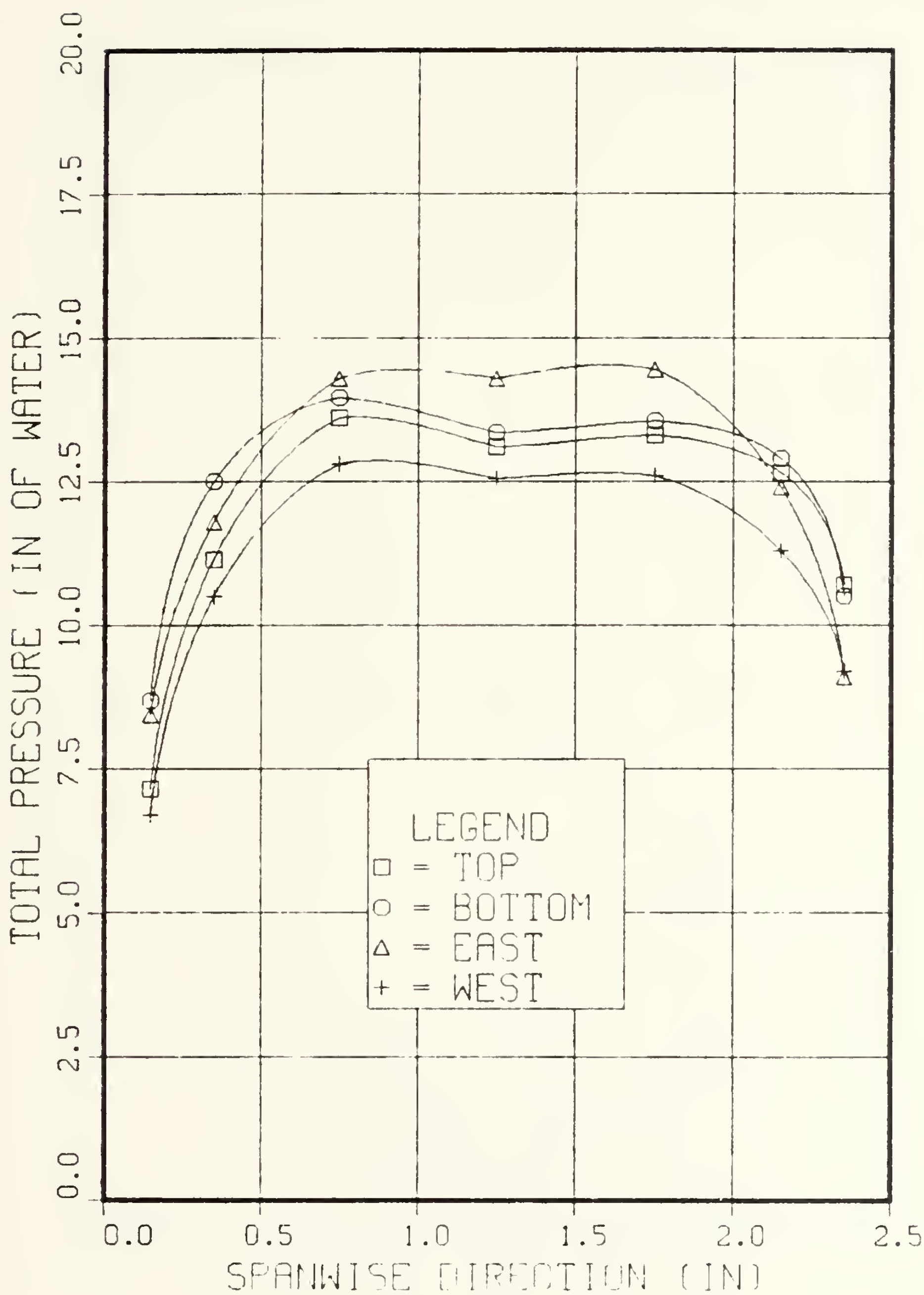
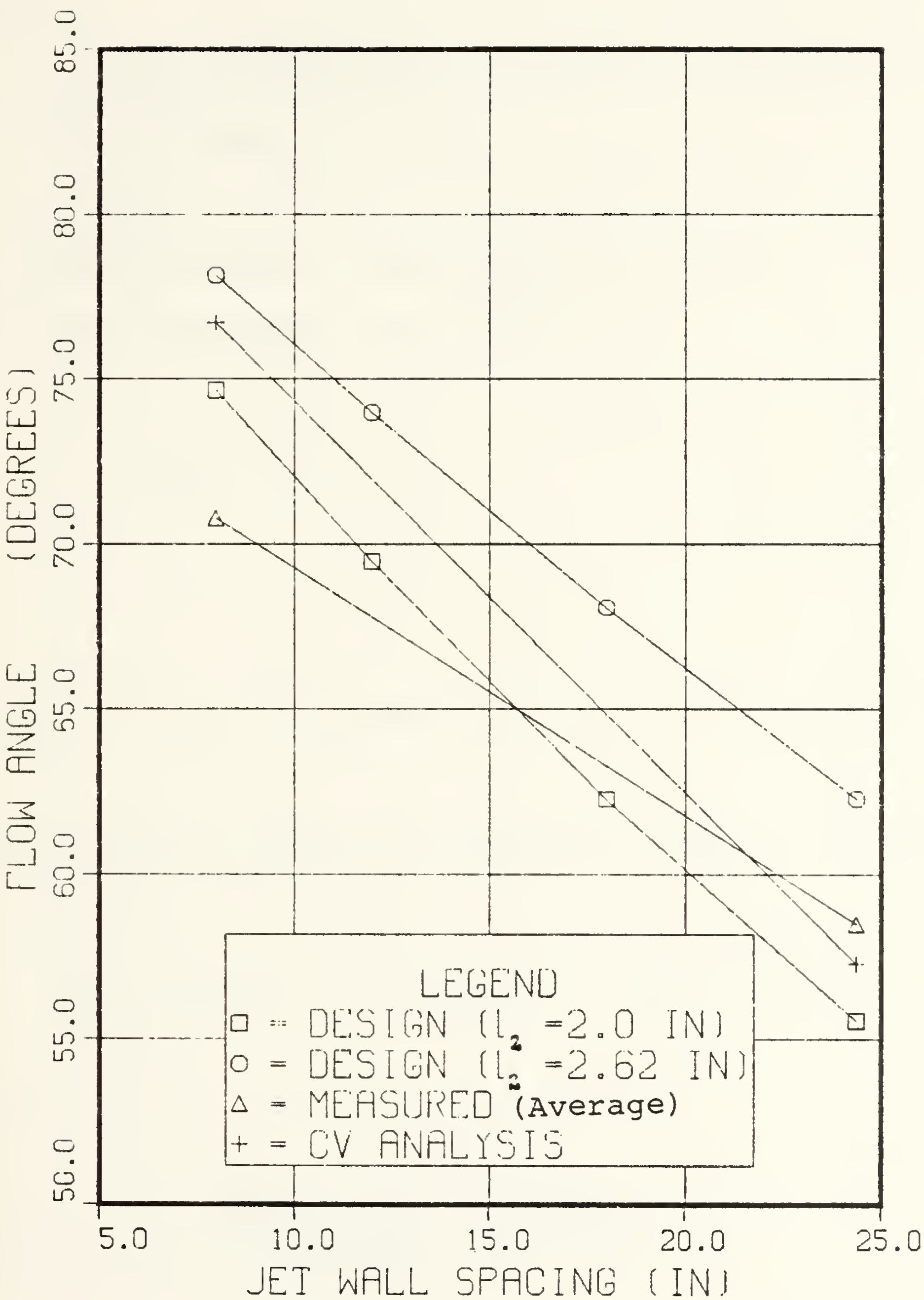


FIGURE 29

COMBINED PLOT OF MEASURED AND CALCULATED FLOW ANGLES.



## APPENDIX A

## CDTD DESIGN CALCULATIONS

Assumptions:

1. The velocity coming out of the JW is the same as at the GC surface (Fig. A1).
2. No losses.
3. Constant density (incompressible) flow.

The velocity components are given by:

$$V_{R_i} = V_i \cos \beta_i \qquad A(1)$$

and

$$V_{\theta_i} = V_i \sin \beta_i \qquad A(2)$$

applying continuity between stations 1 and 2 (Fig. A1).

$$V_{\theta_1} \cdot Z \cdot A_{SV} \cdot N \cdot L_1 + V_{\theta_1} \cdot A_{JW} = V_{R_2} \cdot R_2 (2\pi L_2)$$

so that

$$L_1 = \frac{V_{R_2} R_2 (2\pi L_2) - V_{\theta_1} A_{JW}}{V_{\theta_1} Z A_{SV} N} \qquad A(3)$$

Applying conservation of angular momentum:

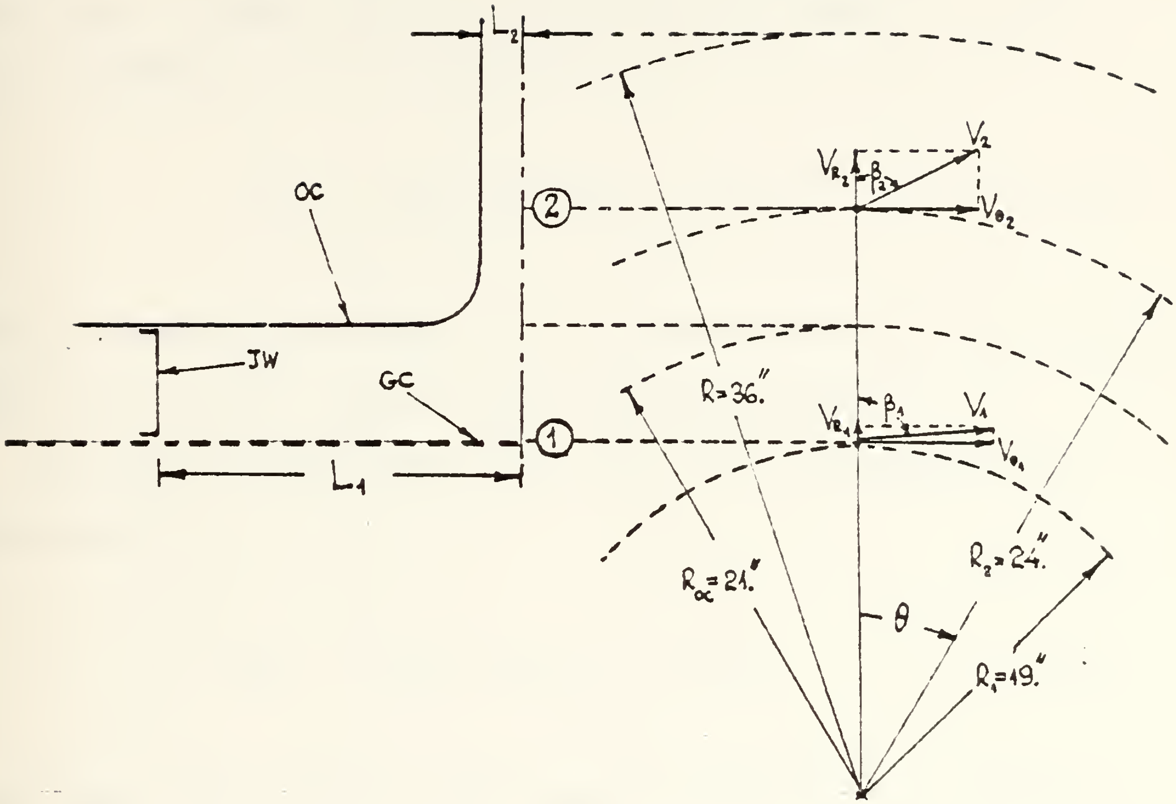



Figure A1. CDTD Schematic for the Design Calculations

$$V_{\theta_1} R_1 = V_{\theta_2} R_2 \qquad A(4)$$

or

$$V_{\theta_1} = V_{\theta_2} \frac{R_2}{R_1} \qquad A(4.1)$$

and substituting in A(3) for $V_{\theta_1}$ from Eq. A(4.1)

$$L_1 = \{\frac{R_1(2\pi L_2)}{ZA_{SV}N}\} \frac{V_{R_2}}{V_{\theta_2}} - \frac{A_{JW}}{ZA_{SV}N} \qquad A(5)$$

Substituting into Eq. A(5) the values for $R_1$, $L_2$, Z, $A_{SV}$, N, and $A_{JW}$, a linear relation is established between $L_1$ and cot $\beta_2$; thus

$$L_1 = 25.97 \cot \beta_2 - 1.458 \qquad A(6)$$

where data have been used for the as-manufactured test section span ($\ell_2$ = 2.61") and the short plywood walls.

For the designed span ($\ell_2^*$ = 2"), and plexiglass walls installed:

$$L_1^* = 19.9 \cot \beta_2 - 1.458 \qquad A(7)$$

Equations A(6) and A(7) can also be solved for $\beta_2$ and $\beta_2^*$; thus

$$\beta_2 = \cot^{-1}(.0385L_1 + .056) \qquad A(8)$$

$$\beta_2 = \cot^{-1}(.05025L_1^* + .07326) \qquad A(9)$$

Using Equations A(8) and A(9) the following Table A1 is obtained:

TABLE A1

FLOW ANGLES ($\beta_2$) AND CORRESPONDING JW SPACING OBTAINED FROM EQUATIONS A(8) AND A(9)

| $\beta_2$ | $\ell_1$ (in) | $\beta_2^*$ | $\ell_1^*$ (in) |
|---|---|---|---|
| 65. | 21.304 | 65 | 15.643 |
| 70. | 15.989 | 70 | 11.57 |
| 75. | 11.001 | 75 | 7.748 |
| 62.29 | 24.375 | 55.56 | 24.375 |
| 68.075 | 18.00 | 62.27 | 18.00 |
| 73.987 | 12.00 | 69.456 | 12.00 |
| 78.14 | 8.00 | 74.663 | 8.00 |
| 79.2 | 7.00 | 76.01 | 7.00 |

## APPENDIX B

## FLOW MODELING CALCULATIONS FOR MERIDL INPUT

Assumptions:

1. Free vortex flow: $V_i R_i$ = constant (from hub to tip at a certain station) and $V_Z$ = constant with radius at constant Z.
2. Constant density $\rho = .076\ LB_m/FT^3$.
3. Total velocity at the inlet of the TS, $V_2$ = 200 FPS
4. Axisymmetric flow.
5. Flow enters from Station 1-1 (Fig. 4) with constant whirl.

Flow Area at TS Inlet

$$A_2 = 2\pi R_2 L_2 = 1.3666\ FT^2$$

$$V_{R_2} = V_2 \cos \beta_2 = 200 \cos \beta_2 \ FPS$$

$$\dot{m}_2 = \rho V_{R_2} A_2 = 20.772 \cos \beta_2 \ Lbm \cdot sec^{-1}$$

Flow Area at Inlet (Station 1-1)

$$A_{IN} = \pi (R_S^2 - R_H^2) = 3.316\ FT^2$$

$$V_Z = \text{constant}$$

Applying continuity between Station 1-1 and at the inlet of the test section:

$$\dot{m} = \rho_1 V_Z A_{IN} = \rho_2 V_{R_2} A_2 \qquad B(1)$$

so that

$$V_Z = V_{R_2} \frac{A_2}{A_{IN}} = .412\ V_{R_2} \qquad B(2)$$

Free vortex flow implies that

$$V_{\theta_1} R_1 = V_{\theta_2} R_2 \qquad B(3)$$

and solving for $V_{\theta_1}$ and inserting values for $R_1$ and $R_2$,

$$V_{\theta_1} = 1.263\ V_{\theta_2} \qquad B(3.1)$$

Also,

$$V_{\theta_2} = V_2 \sin \beta_2 = 200 \sin \beta_2 \text{ (ft/sec)} \qquad B(4)$$

For selected values of $\beta_2$ the following Table B1 was constructed, using the above equations to obtain the corresponding whirl ($R_i V_{\theta_i}$) and the mass flow rate ($\dot{m}$), required as input to MERIDL.

TABLE B1

CALCULATED INPUT PARAMETERS FOR MERIDL CODE

| $\beta_2$ (Deg) | $V_{R_2}$ (Ft/Sec) | $\dot{m}$ (lbs/Sec) | $V_{\theta_2}$ (Ft/Sec) | $V_{\theta_2} R_2$ (Ft$^2$/Sec) |
|---|---|---|---|---|
| 60 | 100 | .3225 | 173.21 | 346.4 |
| 65 | 84.52 | .2726 | 181.26 | 362.5 |
| 70 | 68.4 | .2206 | 187.94 | 375.9 |
| 75 | 51.76 | .167 | 193.19 | 386.4 |

## APPENDIX C

## CALCULATION OF THE MASS AVERAGED FLOW ANGLE

When the flow is non-uniform at the measurement plane, average values can be defined using the conservation equations. For example, applying conservation of angular momentum between the flow entering through the swirl vanes and the test section inlet:

$$\int_{\dot{m}_1} r_1 V_1 \sin\beta_1 d\dot{m}_1 - \int_{\dot{m}_2} r_2 V_2 \sin\beta_2 d\dot{m}_2 = r_1 \overline{\overline{V}}_{\theta_1} \dot{m}_1 - r_2 \overline{\overline{V}}_{\theta_2} \dot{m}_2 \qquad C(1)$$

where $\overline{\overline{V}}_\theta$ is the mass flow average of the tangential velocity component which is defined as:

$$\overline{\overline{V}}_\theta = \frac{1}{\dot{m}} \int_{\dot{m}} V_\theta d\dot{m} \qquad C(2)$$

Similarly conservation of mass gives:

$$\dot{m} = \int_0^{\ell} \rho_2 V_2 \cos\beta_2 (2\pi R_2) d\ell_2 = \int_0^{\ell} \rho_2 (2\pi R_2) V_{R_2} d\ell_2$$

$$= \rho_2 (2\pi R_2) K_{B_2} \overline{\overline{V}}_{R_2} \ell_2 \qquad C(3)$$

where $K_{B_2}$ is defined as the "blockage factor" and relates the area average ($\overline{V}_{R_2}$) and mass average ($\overline{\overline{V}}_{R_2}$) velocity components, thus

$$K_{B_2} = \bar{V}_{R_2}/\bar{\bar{V}}_{R_2} \qquad C(4)$$

Consistent with Eq. C(3) and Eq. C(4) the definition of the area-averaged radial component of velocity is:

$$\bar{V}_{R_2} = \frac{1}{\ell_2}\int_0^{\ell_2} V_{R_2}\, d\ell \qquad C(5)$$

The mass-averaged radial component of velocity is obtained from Eq. E(3), thus

$$\bar{\bar{V}}_{R_2} = \frac{\dot{m}}{\rho_2(2\pi R_2)K_{B_2}\ell_2} \qquad C(6)$$

The mass-averaged flow angle ($\bar{\bar{\beta}}_2$) can be defined from:

$$\tan\bar{\bar{\beta}}_2 = \frac{\bar{\bar{V}}_{\theta_2}}{\bar{\bar{V}}_{R_2}} \qquad C(7)$$

so that

$$\bar{\bar{\beta}}_2 = \tan^{-1}\left(\frac{\bar{\bar{V}}_{\theta_2}}{\bar{\bar{V}}_{R_2}}\right) \qquad C(8)$$

To obtain the value of $\bar{\bar{\beta}}_2$, from probe survey measurements, and blockage factor to use in the control volume analysis (Appendix D), the following data reduction is required:

1. Calculate the area-averaged radial velocity ($\bar{V}_{R_2}$).

$$\bar{V}_{R_2} = \frac{1}{\ell_2} \int_{\ell} V_{R_2} d\ell = \frac{1}{\ell_2} \int_{\ell} V_2 \cos \beta_2 d\ell \qquad C(9)$$

where, if the flow is assumed to be incompressible

$$V_2 = \left[\frac{(P_1 - P_A)}{\rho/2}\right]^{.5} \qquad C(10)$$

Substituting Eq. C(10) into C(9):

$$\bar{V}_{R_2} = \frac{1}{\ell_2} \left(\frac{2}{\rho}\right)^{.5} \int_{\ell_2} (P_1 - P_A)^{.5} \cos \beta_2 d\ell \qquad C(11)$$

where $\beta_2 \equiv \beta_2(\ell)$ is the measured flow angle at the exit of the plywood walls, and $(P_1-P_A)$ is the difference between the total pressure measured by the 5-hole probe and ambient.

2. Calculate the mass-averaged radial velocity using:

$$\bar{\bar{V}}_{R_2} = \frac{1}{\dot{m}} \int_{\dot{m}} V_{R_2} d\dot{m} = \frac{1}{\bar{V}_{R_2} \ell_2} \int_0^{\ell_2} V_{R_2}^2 d\ell \qquad C(12)$$

3. Calculate the blockage factor using:

$$K_{B_2} = \frac{\bar{V}_{R_2}}{\bar{\bar{V}}_{R_2}} \qquad C(13)$$

4. Calculate the mass-averaged tangential velocity using:

$$\bar{\bar{V}}_{\theta_2} = \frac{1}{\dot{m}} \int_{\dot{m}} V_{\theta_2} \, d\dot{m} = \frac{1}{\bar{\bar{V}}_{R_2} \ell_2} \int_0^{\ell_2} V_{\theta_2} V_{R_2} \, d\ell \qquad C(14)$$

5. Calculate $\bar{\bar{\beta}}_2$ using Eq. C(8).

APPENDIX D

CONTROL VOLUME ANALYSIS

1. The equation for $\tan \beta_2$

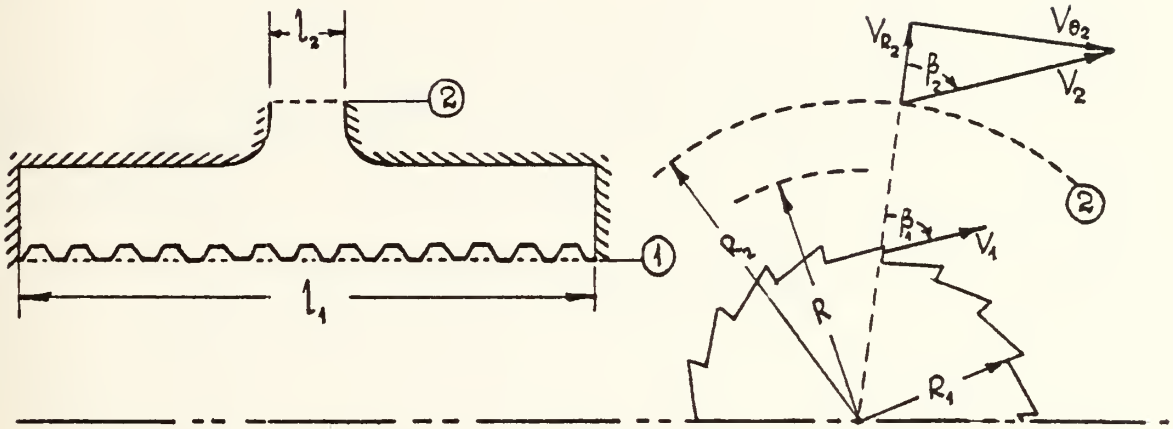



Figure D1. Control Volume Analysis Schematic

Assumptions:

1. Constant density $\rho_1 = \rho_2$

2. Radial inlet surface $S_1$ made up of small nozzles distributed along the GC.

3. The wall surface (IW) consists of:

   a. The outside area of the GC;

   b. The area of the JW faces;

c. Inside area of outer casing up to the test section inlet.

4. Uniform outlet conditions (Station 2).

5. Zero axial velocity ($V_z$) at Stations 1 and 2.

Following Reference 6, the axial moment exerted by the air on the walls of the control volume (Fig. D1) is given by:

$$M_{aw} = \int_{S_1} \bar{R}_1 V_1 \sin\beta_1 d\dot{m}_1 - \int_{S_2} R_2 V_2 \sin\beta_2 d\dot{m}_2$$

$$+ \int_{S_1} \vec{R}_1 \times d\vec{F}_1 + \int_{S_2} \vec{R}_2 \times d\vec{F}_2 \qquad D(1)$$

The force on a surface element can be written in terms of its components normal to and in the surface as:

$$d\vec{F} = - p\hat{n}dS - \tau\hat{t}dS \qquad D(2)$$

so that

$$\int_{S_1} \vec{R}_1 \times d\vec{F}_1 = \int_{S_1} \vec{R}_1 \times (p_1 \hat{n} dS)$$

$$= \bar{R}_1 p_1 A_1 N \ell_1 Z \qquad D(3)$$

From continuity

$$\dot{m} = \int_{S_1} d\dot{m}_1 = \int_{S_2} d\dot{m}_2 \qquad D(4)$$

so that

$$\int_{S_1} d\dot{m}_1 = \rho_1 V_1 \sin\beta_1 \; k_{B_1} A_1 Z N \ell_1 \qquad D(4.1)$$

and

$$\int_{S_2} d\dot{m}_2 = \rho_2 V_2 \cos\beta_2 \; k_{B_2} (2\pi R_2) \ell_2 \qquad D(4.2)$$

Substituting Eq. D(3), D(4.1) and D(4.2) into D(1):

$$M_{aw} = \rho_1 \bar{R}_1 V_1^2 \sin^2\beta_1 \; kB_1 A_1 Z N \ell_1 + \bar{R}_1 p_1 A_1 Z N \ell_1$$

$$- \rho_2 R_2 V_2^2 \sin\beta_2 \cos\beta_2 \; kB_2 (2\pi R_2) \ell_2 \qquad D(5)$$

The different terms in the LHS of Equation D(5), can be written in terms of the moments of the normal and tangential stress components given in Equation D(2). The only contributions to the axial moment, comes from shear stress components ($\tau$) on the cylindrical walls, and normal stress components ($p_w$) on the non cylindrical surfaces of the swirl vanes.
Thus:

$$M_{aw} = \int_{IW} \tau \; R \; dS + \int_a^b p_w R \sin\theta \; dS' \qquad D(6)$$

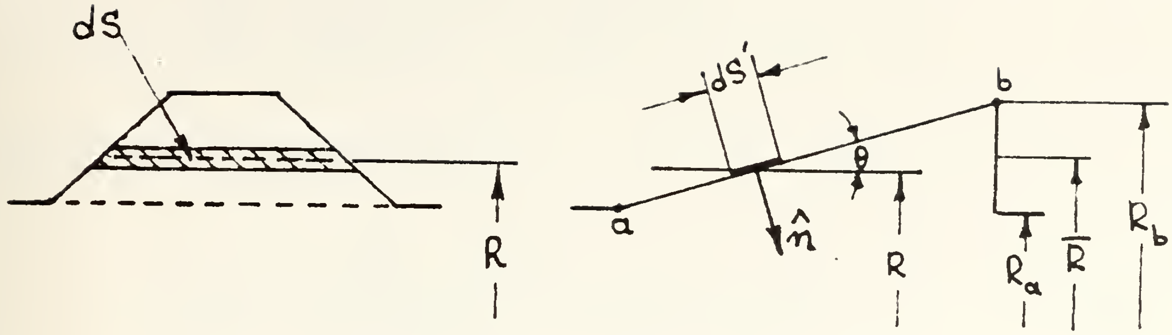



Figure D2. Stress Components on the Swirl Vanes

From Figure D2,

$$dS = dS' \sin \theta \qquad D(7)$$

so that

$$M_{aw} = \int_{IW} \tau \, R \, dS + ZN\ell_1 \int_a^b p_w R dS \qquad D(8)$$

Combining Equations D(5) and D(8)

$$\int_{IW} \tau R dS + ZN\ell_1 \int_a^b (p_w - p_1) R dS = \dot{m}(\bar{R}_1 V_1 \sin \beta_1 - R_2 V_2 \sin \beta_2) \qquad D(9)$$

Solving Equation D(9) for $\sin \beta_2$, dividing both sides by $\cos \beta_2$, and substituting $V_1$ and $V_2$ from Equations D(4.1) and D(4.1), we obtain:

$$\tan \beta_2 = \frac{\bar{R}_1}{R_2} \times \left[\frac{K_{B_2}(2\pi R_2)}{K_{B_1} A_{SV}}\right] \times \left\{\frac{\ell_2}{\ell_1}\right\} \times \{1 - C_p - C_\tau\} \qquad D(10)$$

where, the pressure term

$$C_p = \frac{ZN\ell_1}{\dot{m}V_1 \sin \beta_1} \int_a^b (p_w - p_1) \frac{R}{\bar{R}_1} dS \qquad D(11)$$

and the friction term

$$C_\tau = \frac{1}{\dot{m}V_1 \sin \beta_1} \int_{IW} \tau \frac{R}{\bar{R}_1} dS \qquad D(12)$$

The design analysis in Appendix A is the special case of $C_p = C_\tau = 0$. The values of $C_p$ and $C_\tau$ can be obtained using various assumptions.

2. Calculation of the Pressure Term

Writing,

$$\int_a^b \frac{R}{\bar{R}_1} dS \simeq A_{SV} k_{B_1}$$

and $(p_w - p_1) \neq f(R)$, then

$$C_p \simeq \frac{ZN\ell_1 A_{SV} K_{B_1}}{\dot{m}V_1 \sin \beta_1} (p_w - p_1) \qquad D(13)$$

where $(p_w - p_1)$ has a maximum value of $(p_{t_1} - p_1)$, or more realistically, $(p'_{t_1} - p_1)$, where $p'_{t_1}$ is the stagnation pressure after jet mixing.

In order to calculate $p'_{t1}$, a sudden expansion is assumed downstream the swirl vanes. The following formula, derived in Reference 4, results from mixing at constant pressure:

$$\frac{p_w - p_1}{\frac{1}{2}\rho_1 V_1^2} = 2\,\frac{A_1}{A_{MIX}}\left(1 - \frac{A_1}{A_{MIX}}\right) \qquad D(14)$$

where $A_{MIX}$ is the area of the flow when total mixing has occurred and the velocity is uniform.

From experimental measurements (Fig. D3), it was estimated that total mixing occurs within .3" from the GC surface, so as shown in Fig. D4 the area ratio is given by:

$$A_1/A_{MIX} = .3916$$

hence Equation D(14) becomes

$$p_w - p_1 = \frac{1}{2}\rho V_1^2 \times (.4765) \qquad D(15)$$

Substituting to Equation D(13), the pressure term becomes:

$$C_p = \frac{(.23875)}{\sin^2\beta_1} \qquad D(16)$$

It is noted that the pressure term changes the value of $\tan\beta_2$ by nearly 25%.

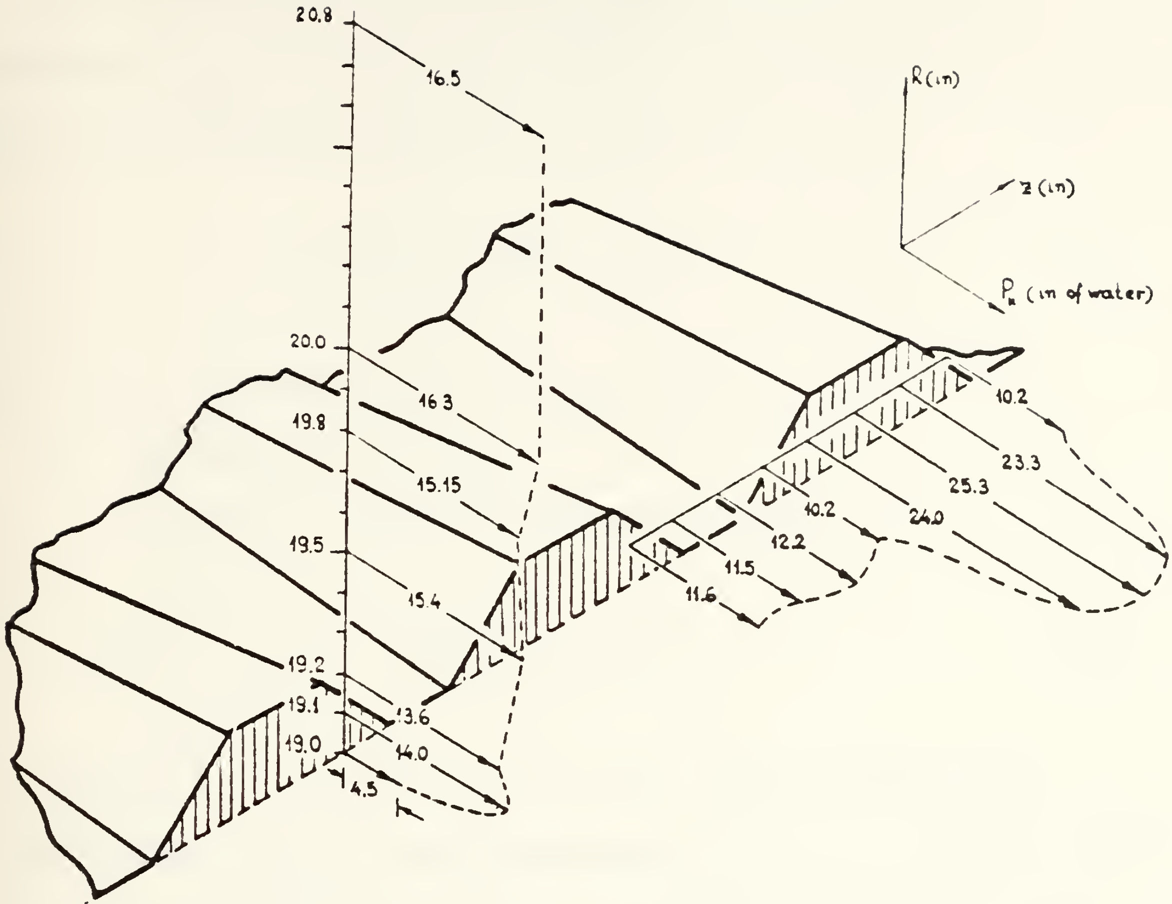



Figure D3. Total Pressure Distribution in the Flow Generator and Near the Surface of the Generating Cylinder Measured with a Kiel Probe

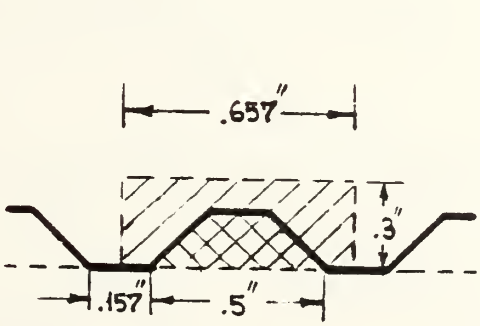



Figure D4. $A_1/A_{MIX}$ Area Ratio Schematic

3. Calculation of the Friction Term

The friction term is approximated using an average velocity ($\overline{V}_{IW}$) for the flow over the inner walls of the CDTD; the tangential stress is given by:

$$\tau = \frac{1}{2} C_F \rho \overline{V}^2_{IW} \qquad D(17)$$

and values are required for $\overline{V}_{IW}$ and $C_F$.

a. Calculation of $\overline{V}_{IW}$

In terms of Kiel probe measurements,

$$V_1 = [\frac{p_K - p_A}{\rho/2}(5.202)]^{.5} \qquad D(18)$$

From Fig. D3 and using Eq. D(18) with the pressure differences ($p_K$-$p_A$) from measurements and $\rho$ = .002766 <slugs/ FT$^3$>, the following Table D1 is obtained, for the velocity profile close to the surface of the GC.

Define the blockage factor for one jet as:

$$K_{B_1} = \frac{\int_5^9 V_1(z)dz}{(z_9 - z_5)V_{1_{MAX}}} = .841 \qquad D(19)$$

where the average inlet velocity is given by

$$\overline{V}_1 = V_{1_{MAX}} \times K_{B_1} = 183.45 \text{ ft/sec} \qquad D(20)$$

TABLE D1

VELOCITY PROFILE CALCULATION AT THE SURFACE OF THE GENERATING CYLINDER

| Point # | $2(p_K - p_A)$ (in $H_2O$) | $V_1$ (FPS) |
|---|---|---|
| 1 | 14.0 | 162.0 |
| 2 | 11.6 | 147.7 |
| 3 | 11.5 | 147.06 |
| 4 | 12.2 | 151.5 |
| 5 | 10.2 | 138.5 |
| 6 | 24.0 | 212.45 |
| 7 | 25.3 | 218.13 |
| 8 | 23.3 | 209.33 |
| 9 | 10.2 | 138.5 |

The velocity over the outer casing walls ($V_{OW}$) can be approximated from the pressure difference to atmosphere measured at R = 20.8" (Fig. D4), then

$$V_{OW} = [\frac{\Delta P \ (R = 20.8")}{\rho/2}(5.202)]^{.5} = 176.16 \text{ FPS} \qquad D(21)$$

From Equations D(20) and D(21) the average velocity over the inner walls ($\overline{V}_{IW}$) can be estimated:

$$\overline{V}_{IW} = \frac{\overline{V}_1 + V_{OW}}{2} = 179.8 \text{ FPS} \qquad D(22)$$

b. Calculation of $C_F$

The hydraulic diameter [Ref. 5] is used to calculate the Reynolds number. The Reynolds number is given by:

$$Re = \frac{d_h \bar{V}_{IW}}{\nu} \qquad D(23)$$

where

$$d_h = \frac{4A}{C} \qquad D(24)$$

and A denotes the cross-sectional area and C the wetted perimeter.

For the CDTD

$$A = 2\ell_1 + 4\ell_2 \equiv .41 \text{ FT}^2$$

$$C = 2\ell_1 + 12 \equiv 5.0625 \text{ FT}$$

hence

$$d_h = .324 \text{ FT} \qquad D(24.1)$$

For $\nu = 1.57 \times 10^{-4}$ FT$^2$/sec, Eq. D(23) gives:

$$Re = 3.63 \times 10^5 \qquad D(25)$$

From Prandtl's universal law of friction for turbulent flows through pipes [Ref. 5]:

$$C_F = 3.59 \times 10^{-3} \qquad D(26)$$

Substituting all specified terms into Eq. D(12):

$$C_\tau = \frac{1.795 \times 10^{-3}}{\sin^2 \beta_1} \times \left(\frac{A_{IW}}{A_{T1}}\right) \left(\frac{\bar{V}_{IW}}{\bar{V}_1}\right)^2 \qquad D(27)$$

4. Calculation of Outlet Angle

Using Eq. D(16) and Eq. D(27) in Eq. D(10),

$$\tan \beta_2 = \frac{\bar{R}_1}{R_2} \times \left(\frac{A_{T2}}{A_{T1}}\right) \left[1 - \frac{.23875}{\sin^2 \beta_1} - \frac{1.795 \times 10^{-3}}{\sin^2 \beta_1} \left(\frac{\bar{V}_{IW}}{\bar{V}_1}\right)^2 \left(\frac{A_{IW}}{A_{T1}}\right)\right]$$

D(28)

For the values:

$\bar{R}_1 = 19.1$ in

$R_2 = 25$ in

$\ell_2 = 2.62$ in

$A_{T1} = A_{SV} ZN \ell_1 k_{B_1} = 5.045 \ell_1$ in

$k_{B_2}$ ($\ell_1 = 24.375$) = .925 (average measured)

$k_{B_2}$ ($\ell_1 = 8.0$) = .83 (average measured)

$$A_{T2} = 2\pi R_2 \ell_2 k_{B_2} = 411.55\ k_{B_2}\ \text{in}^2$$

$$A_{IW} \doteq 2\pi \bar{R}_1 \ell_1 + 2\pi R_{OC}(\ell_1 - \ell_2) + 2\pi(R_{OC}^2 - R_1^2) + 2\pi(R_2^2 - R_{OC}^2)$$

$$= 7454\ \text{in}^2$$

$$\beta_1 = 84°$$

Substituting these values into Eq. D(28), the flow angle as a function of the exposed length ($\ell_1$) of the generating cylinder (since $k_{B_2}$ is also a function of $\ell_1$) is given by:

$$\beta_2 = \tan^{-1}[(40.78)\{\frac{k_{B_2}}{\ell_1}\}] \qquad D(29)$$

From Eq. D(29), for $\ell_1 = 24.375"$ and $k_{B_2} = .925$:

$$\beta_2\ (\ell_1 = 24.375) = 57.13°$$

Also, for $\ell_1 = 8.0$ in and $k_{B_2} = .83$; Eq. D(29) gives:

$$\beta_2\ (\ell_1 = 8.0) = 76.7° .$$

# APPENDIX E

## MERIDL INPUT FILES

```
                    *********************
                    *      MERIDL       *
                    *   PROGRAM INPUT   *
                    *********************

CDTO  TS USING MERDIL (L2 = 1.305 IN)  B2 = 60.   8/9/83

 GENERAL  INPUT  DATA
   GAP              AR             MSFL          OMEGA          REDFAC          VELTOL         FNEW        ONEW
 1.400000        1716.000        .3225000      .0             1.000000        .1000000E-01   .5000000    .5000000
   VELTOL   HAS  BEEN  REDUCED  BY  THE  MINIMUM  OF  FNEW  OR  ONEW  TO  =   VELTOL
                                                                               .4999999E-02
   MBI    MBO    MM    MHT    NBL    NHUB   NTIP    NIN    NOUT   NBLPL  NPPP  NOSTAT  NSL   NLOSS
    0      0     30    10      1      13     15      9      6      0      0     0      22     0
  LSFR   LTPL   LAMVT  LROT   LBLAD  LETEAN
    1      1      0     1      0      0
  ANGROT
 45.00000

 HUB  AND  SHROUD  INPUT  DATA
   ZOMIN         ZOMBI          ZOMBO          ZOMOUT         ROMIN          ROMBI          ROMBO          ROMOUT
 .5000000       .0             .0             2.025400       1.416700       .0             .0             2.474500
   ZHUB  ARRAY
 .5000000       .7500000       1.000000       1.250000       1.500000       1.750000       1.858700       1.942100
 2.000000       2.025400       2.025400       2.025400       2.025400
   RHUB  ARRAY
 1.416670       1.416670       1.416670       1.416670       1.416670       1.416670       1.416670       1.439000
 1.500000       1.583300       1.750000       2.000000       2.474600
   ZTIP  ARRAY
 .5000000       .7500000       1.000000       1.250000       1.500000       1.750000       1.791700       1.833300
 1.675000       1.891700       1.934200       1.908300       1.916700       1.916700       1.916700
   RTIP  ARRAY
 1.750000       1.750000       1.750000       1.750000       1.750000       1.750000       1.755600       1.775400
 1.822500       1.853800       1.887500       1.906250       2.000000       2.250000       2.500000

 UPSTREAM  INPUT  DATA
   ZHIN          ZTIN           PHIN           RTIN
 .5000000       .5000000       1.416670       1.750000
   RADIN  ARRAY
 1.416670       1.458340       1.500000       1.541670       1.583340       1.625000       1.666670       1.708330
 1.750000
   TIP  ARRAY
 520.0000       520.0000       520.0000       520.0000       520.0000       520.0000       520.0000       520.0000
 520.0000
   PRIP  ARRAY
 2116.000       2116.000       2116.000       2116.000       2116.000       2116.000       2116.000       2116.000
 2116.000
   LAMIN  ARRAY
 346.4199       346.4199       346.4199       346.4199       346.4199       346.4199       346.4199       346.4199
 346.4199

 DOWNSTREAM  INPUT  DATA
   ZHOUT         ZTOUT          RHOUT          RTOUT
 2.025400       1.916670       2.474600       2.583300
   RADOUT  ARRAY
 2.474600       2.500000       2.520800       2.541700       2.562500       2.583330
   LOSOUT  ARRAY
 .9999999E-03   .9999999E-03   .9999999E-03   .9999999E-03   .9999999E-03   .9999999E-03
```

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                        **********************
                        *       MERIDL       *
                        *   PROGRAM INPUT    *
                        **********************

CDTD  IS USING PERDIL (L2 = 1.305 IN)  B2 = 65.   8/9/83


GENERAL  INPUT  DATA
   GAM          AR           MSFL          OMEGA          REDFAC          VELTOL          FNEW          DNEW
1.400000     1716.000     .2726000       .0             1.000000       .1000000E-01    .5000000      .5000000
VELTOL   HAS  BEEN  REDUCED  BY  THE  MINIMUM  OF  FNEW  OR  DNEW  TO  =   VELTOL
                                                                         .4999999E-02
  MBI    MBC    MM     MIT    NBL   NHUB   NTIP    NIN    NOUT    NBLPL   NPPP  NOSTAT   NSL    NLOSS
   0      0     30     10      1     13     15      9      6       0       0     0      22      0
 LSFR   LTPL   LAPVT  LHUT   LBLAD  LETEAN
   1      1      0      1      0      0
 ANCROT
 45.00000


HUB  AND  SHROUD  INPUT  DATA
  ZOMIN        ZOMBI        ZOMBO        ZOMOUT       ROMIN        ROMBI        ROMBC        ROMOUT
 .5000000     .0           .0           2.025400     1.416700     .0           .0           2.474600
  ZHUB  ARRAY
 .5000000     .7500000     1.000000     1.250000     1.500000     1.750000     1.858700     1.942100
 2.000000     2.025400     2.025400     2.025400     2.025400
  RHUB  ARRAY
 1.416670     1.416670     1.416670     1.416670     1.416670     1.416670     1.416670     1.439000
 1.500000     1.583300     1.750000     2.000000     2.474600
  ZTIP  ARRAY
 .5000000     .7500000     1.000000     1.250000     1.500000     1.750000     1.791700     1.833300
 1.675000     1.851700     1.904200     1.908300     1.916700     1.916700     1.916700
  RTIP  ARRAY
 1.750000     1.750000     1.750000     1.750000     1.750000     1.750000     1.755600     1.775400
 1.822500     1.853800     1.887500     1.906250     2.000000     2.250000     2.500000


UPSTREAM  INPUT  DATA
  ZHIN         ZTIN         RHIN         RTIN
 .5000000     .5000000     1.416670     1.750000
  RADIN  ARRAY
 1.416670     1.458340     1.500000     1.541670     1.583340     1.625000     1.666670     1.708330
 1.750000
  TIP  ARRAY
 520.0000     520.0000     520.0000     520.0000     520.0000     520.0000     520.0000     520.0000
 520.0000
  PRIP  ARRAY
 2116.000     2116.000     2116.000     2116.000     2116.000     2116.000     2116.000     2116.000
 2116.000
  LAPIN  ARRAY
 362.5200     362.5200     362.5200     362.5200     362.5200     362.5200     362.5200     362.5200
 362.5200


DOWNSTREAM  INPUT  DATA
  ZHOUT        ZTOUT        RHOUT        RTOUT
 2.025400     1.916670     2.474600     2.583300
  RADOUT  ARRAY
 2.474600     2.500000     2.520800     2.541700     2.562500     2.583330
  LLSOUT  ARRAY
 .9999999E-03 .9999999E-03 .9999999E-03 .9999999E-03 .9999999E-03 .9999999E-03


OUTPUT  STREAMLINE  FLOW  FRACTION  DATA
  FLFR  ARRAY
 .0           .5000000E-01 .1000000     .1500000     .2000000     .2500000     .3000000     .3500000
 .4000000     .4500000     .4750000     .5000000     .5500000     .6000000     .6500000     .7000000
 .7500000     .8000000     .8500000     .9000000     .9500000     1.000000
```

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                                        *********************
                                        *      MERIDL       *
                                        *   PROGRAM INPUT   *
                                        *********************

COLD  IS USING MERDIL (L2 = 1.305 IN)  B2 = 70.   8/9/83

  GENERAL  INPUT  DATA
    GAM            AR              MSFL            OMEGA           REDFAC          VELTOL          FNEW            ONEW
  1.400000       1716.000        .2206000        .0              1.000000        .1000000E-01    .5000000        .5000000
    VELTOL   HAS  BEEN  REDUCED  BY  THE  MINIMUM  OF  FNEW  OR  ONEW  TO  =     VELTOL
                                                                                 .4599999E-02
     MBI     MBO     MM      MHI     NBL     NHUB    NTIP     NIN     NOUT    NPLPL   NPPP   NOSTAT   NSL    NLOSS
      0       0      30      10       1       13      15       9       6       0       0       0      22      0
    LSFR    LIPL    LAMVI   LROT    LBLAD   LETEAN
      1       1       0       1       C       0
    ANGROT
   45.C0000

  HUB  AND  SHROUD  INPUT  DATA
    ZOMIN          ZLMBI           ZOMBO           ZOMOUT          ROMIN           ROMBI           ROMBO           ROMOUT
   .5000000       .0              .0              2.025400        1.416700        .0              .0              2.474600
    ZHUB   ARRAY
   .5000000       .7500000        1.000000        1.250000        1.500000        1.750000        1.858700        1.942100
   2.000100       2.025400        2.025400        2.025400        2.025400
    RHUB   ARRAY
   1.416670       1.416670        1.416670        1.416670        1.416670        1.416670        1.416670        1.439000
   1.500000       1.583300        1.750000        2.000000        2.474600
    ZTIP   ARRAY
   .5000000       .7500000        1.000000        1.250000        1.500000        1.750000        1.791700        1.833300
   1.875000       1.891700        1.904200        1.908300        1.916700        1.916700        1.916700
    RTIP   ARRAY
   1.750000       1.750000        1.750000        1.750000        1.750000        1.750000        1.755600        1.775400
   1.822500       1.852800        1.887500        1.906250        2.000000        2.250000        2.500000

  UPSTREAM  INPUT  DATA
    ZFIN           ZTIN            RHIN            RTIN
   .5000000       .5000000        1.416670        1.750000
    RADIN   ARRAY
   1.416670       1.458340        1.500000        1.541670        1.583340        1.625000        1.666670        1.708330
   1.750000
    TIP   ARRAY
   520.0000       520.0000        520.0000        520.0000        520.0000        520.0000        520.0000        520.0000
   520.0000
    PRIP   ARRAY
   2116.000       2116.000        2116.000        2116.000        2116.000        2116.000        2116.000        2116.000
   2116.000
    LAMIN   ARRAY
   375.8799       375.8799        375.8799        375.8799        375.8799        375.8799        375.8799        375.8799
   375.8799

  DOWNSTREAM  INPUT  DATA
    ZFOUT          ZICUT           RHOUT           RTOUT
   2.025400       1.916670        2.474600        2.583300
    RADOUT   ARRAY
   2.474600       2.500000        2.520800        2.541700        2.562500        2.583330
    LOSOUT   ARRAY
   .9999999E-03   .9999999E-03    .9999999E-03    .9999999E-03    .9999999E-03    .9999999E-03

  OUTPUT  STREAMLINE  FLOW  FRACTION  DATA
    FLFR   ARRAY
   .0             .5000000E-01    .1000000        .1500000        .2000000        .2500000        .3000000        .3500000
   .4000000       .4500000        .4750000        .5000000        .5500000        .6000000        .6500000        .7000000
   .7500000       .8000000        .8500000        .9000000        .9500000        1.000000
```

```
                         *********************
                         *       MERIDL      *
                         *   PROGRAM INPUT   *
                         *********************

CDTC  IS USING MERDIL (L2 = 1.305 IN)  B2 - 75.   8/9/83


  GENERAL  INPUT  DATA
     DAM         AR            MSFL          OMEGA          REDFAC          VELTOL        FNEW        ONEW
   1.400000    1716.000      .1680000       .0             1.000000       .1000000E-01  .5000000    .5000000
     VELTOL  HAS  BEEN  REDUCED  BY  THE  MINIMUM  OF  FNEW  OR  ONEW  TO  *   VELTOL
                                                                           .4999999E-02
     MBI    MBC    MM     MIT    NBL   NHUB   NTIP    NIN   NOUT   NBLPL  NPPP  NUSTAT   NSL   NLOSS
      0      C     30     10      1     13     15      9     6      0      0      0      22     0
    LSFR   LTFL   LAMVT  LROT   LBLAD  LETEAN
      1      1      0      1      C      0
    ANGROT
   45.00000


  HUB  AND  SHROUD  INPUT  DATA
     ZCMIN       ZCMBI        ZCMBC        ZCMOUT       RCMIN        RCMBI        RCMBO        RCMOUT
   .5000000    .0           .0           2.025400     1.416700     .0           .0           2.474600
     ZHUB  ARRAY
   .5000000    .7500000     1.000000     1.250000     1.500000     1.750000     1.858700     1.942100
   2.003100    2.025400     2.025400     2.025400     2.025400
     RHUB  ARRAY
   1.416670    1.416670     1.416670     1.416670     1.416670     1.416670     1.416670     1.439000
   1.500000    1.583300     1.750000     2.000000     2.474600
     ZTIP  ARRAY
   .5000000    .7500000     1.000000     1.250000     1.500000     1.750000     1.791700     1.833300
   1.875000    1.851700     1.904200     1.908300     1.916700     1.916700     1.916700
     RTIP  ARRAY
   1.750000    1.750000     1.750000     1.750000     1.750000     1.750000     1.755600     1.775400
   1.822500    1.853800     1.887500     1.906250     2.000000     2.250000     2.500000


  UPSTREAM  INPUT  DATA
     ZHIN        ZTIN         RHIN         RTIN
   .5000000    .5000000     1.416670     1.750000
     RADIN  ARRAY
   1.416670    1.458340     1.500000     1.541670     1.583340     1.625000     1.666670     1.708330
   1.750000
     TIP  ARRAY
   520.0000    520.0000     520.0000     520.0000     520.0000     520.0000     520.0000     520.0000
   520.0000
     PRIP  ARRAY
   2116.000    2116.000     2116.000     2116.000     2116.000     2116.000     2116.000     2116.000
   2116.000
     CAPI.  ARRAY
   386.3701    386.3701     386.3701     386.3701     386.3701     386.3701     386.3701     386.3701
   386.3701


  DOWNSTREAM  INPUT  DATA
     ZHOUT       ZTOUT        RHOUT        RTOUT
   2.025400    1.916670     2.474600     2.583300
     RADOUT  ARRAY
   2.474600    2.500000     2.520800     2.541700     2.562500     2.583330
     LOSOUT  ARRAY
   .9999999E-03  .9999999E-03  .9999999E-03  .9999999E-03  .9999999E-03  .9999999E-03


  OUTPUT  STREAMLINE  FLOW  FRACTION  DATA
     FLFR  ARRAY
   .0          .5000000E-01  .1000000    .1500000     .2000000     .2500000     .3000000     .3500000
   .4000000    .4500000     .4750000     .5000000     .5500000     .6000000     .6500000     .7000000
   .7500000    .8000000     .8500000     .9000000     .9500000     1.000000
```

# APPENDIX F

## MERIDL OUTPUT FILES

*** STREAM FUNCTION, INTERIOR VELOCITIES, VELOCITY COMPONENTS, ANGLES, AND SURFACE VELOCITIES ***
ALONG STREAMLINES

FULL MASSFLOW
ITERATION NO. 3

** STREAMLINE NUMBER 1 — STREAM FUNCTION = 0.0 **

| AXIAL COORD. (Z) | RADIAL COORD. (R) | MERID. COORD. (M) | MERID. VEL. (WM) | REL.TANG. VEL. (WTH) | REL. VEL. (W) | CRIT.VEL. RATIO (W/WCR) | MERID. ANGLE (ALPHA) | REL.FLOW ANGLE (BETA) | STREAM. CURV. (1./DIST) | SUCT.SUR. VEL. (WS) | PRES.SUR. VEL. (WP) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .50003 | 1.4167 | .0 | 42.08 | 244.53 | 248.13 | 0.243 | 0.01 | 80.23 | -.9269E-03 | 0.0 | 0.0 |
| .58910 | 1.4167 | .89069E-01 | 42.08 | 244.53 | 248.12 | 0.243 | 0.00 | 80.24 | -.1364E-02 | 0.0 | 0.0 |
| .67818 | 1.4167 | .17315 | 42.12 | 244.53 | 248.13 | 0.243 | -0.00 | 80.23 | -.1375E-02 | 0.0 | 0.0 |
| .76727 | 1.4167 | .26124 | 42.16 | 244.53 | 248.14 | 0.243 | -0.01 | 80.22 | -.3773E-03 | 0.0 | 0.0 |
| .85637 | 1.4166 | .35634 | 42.21 | 244.54 | 248.15 | 0.243 | -0.01 | 80.21 | .1877E-02 | 0.0 | 0.0 |
| .94545 | 1.4166 | .44542 | 42.25 | 244.54 | 248.16 | 0.243 | 0.01 | 80.20 | .5978E-02 | 0.0 | 0.0 |
| 1.0345 | 1.4167 | .53445 | 42.33 | 244.53 | 248.16 | 0.243 | 0.05 | 80.18 | .4720E-02 | 0.0 | 0.0 |
| 1.1235 | 1.4168 | .62343 | 42.43 | 244.51 | 248.16 | 0.243 | 0.05 | 80.15 | -.1715E-01 | 0.0 | 0.0 |
| 1.2126 | 1.4168 | .71253 | 42.45 | 244.51 | 248.17 | 0.243 | -0.12 | 80.15 | -.3337E-01 | 0.0 | 0.0 |
| 1.3020 | 1.4164 | .80199 | 42.18 | 244.58 | 248.19 | 0.243 | -0.28 | 80.21 | .2526E-01 | 0.0 | 0.0 |
| 1.3913 | 1.4162 | .89127 | 41.96 | 244.61 | 248.17 | 0.243 | 0.11 | 80.20 | .1037 | 0.0 | 0.0 |
| 1.4706 | 1.4170 | .97755 | 41.82 | 244.48 | 248.03 | 0.243 | 0.77 | 80.29 | -.1147E-02 | 0.0 | 0.0 |
| 1.5678 | 1.4179 | 1.0678 | 41.16 | 244.33 | 247.77 | 0.243 | 0.12 | 80.44 | -.1932 | 0.0 | 0.0 |
| 1.6579 | 1.4168 | 1.1579 | 38.15 | 244.50 | 247.46 | 0.243 | -1.22 | 81.13 | -.5237E-01 | 0.0 | 0.0 |
| 1.7496 | 1.4152 | 1.2486 | 32.58 | 244.73 | 246.94 | 0.242 | -0.40 | 82.42 | .4869 | 0.0 | 0.0 |
| 1.8357 | 1.4170 | 1.3359 | 25.10 | 244.47 | 245.76 | 0.241 | 3.62 | 84.14 | 1.801 | 0.0 | 0.0 |
| 1.9133 | 1.4287 | 1.4142 | 18.26 | 242.47 | 243.16 | 0.238 | 15.71 | 85.69 | 4.[illegible]8 | 0.0 | 0.0 |
| 1.9721 | 1.4590 | 1.4803 | 15.27 | 237.44 | 237.93 | 0.233 | 41.32 | 86.32 | 6.548 | 0.0 | 0.0 |
| 2.0046 | 1.5115 | 1.5443 | 17.36 | 229.19 | 229.85 | 0.225 | 67.47 | 85.67 | 5.665 | 0.0 | 0.0 |
| 2.0253 | 1.5839 | 1.6186 | 25.26 | 218.71 | 220.17 | 0.216 | 84.34 | 83.41 | 2.757 | 0.0 | 0.0 |
| 2.0276 | 1.6706 | 1.7053 | 40.67 | 207.36 | 211.31 | 0.207 | 91.05 | 78.[illegible] | .7070 | 0.0 | 0.0 |
| 2.0252 | 1.7621 | 1.7969 | 63.14 | 196.59 | 206.48 | 0.202 | 91.20 | 72.19 | -.9057E-01 | 0.0 | 0.0 |
| 2.0242 | 1.8522 | 1.8870 | 85.97 | 187.03 | 205.84 | 0.202 | 90.12 | 65.31 | -.1660 | 0.0 | 0.0 |
| 2.0246 | 1.9409 | 1.9757 | 98.31 | 178.48 | 203.77 | 0.200 | 89.49 | 61.15 | -.7857E-01 | 0.0 | 0.0 |
| 2.0255 | 2.0290 | 2.0638 | 98.58 | 171.73 | 197.35 | 0.193 | 89.31 | 59.90 | .1153E-01 | 0.0 | 0.0 |
| 2.0264 | 2.1172 | 2.1520 | 94.93 | 163.62 | 189.19 | 0.185 | 89.61 | 59.36 | .6453E-01 | 0.0 | 0.0 |
| 2.0267 | 2.2060 | 2.2408 | 90.37 | 157.03 | 181.18 | 0.178 | 89.98 | 60.08 | .5953E-01 | 0.0 | 0.0 |
| 2.0265 | 2.2953 | 2.3300 | 86.36 | 150.91 | 173.89 | 0.170 | 90.22 | 60.22 | .3852E-01 | 0.0 | 0.0 |
| 2.0261 | 2.3848 | 2.4196 | 83.34 | 145.26 | 167.47 | 0.164 | 90.37 | 60.16 | .2617E-01 | 0.0 | 0.0 |
| 2.0254 | 2.4746 | 2.5094 | 81.29 | 137.94 | 161.88 | 0.159 | 90.49 | 59.86 | .1746E-01 | 0.0 | 0.0 |

** STREAMLINE NUMBER 2 — STREAM FUNCTION = 0.0500 **

| AXIAL COORD. (Z) | RADIAL COORD. (R) | MERID. COORD. (M) | MERID. VEL. (WM) | REL.TANG. VEL. (WTH) | REL. VEL. (W) | CRIT.VEL. RATIO (W/WCR) | MERID. ANGLE (ALPHA) | REL.FLOW ANGLE (BETA) | STREAM. CURV. (1./DIST) | SUCT.SUR. VEL. (WS) | PRES.SUR. VEL. (WP) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .50003 | 1.4352 | .0 | 41.97 | 241.41 | 245.03 | 0.240 | 0.01 | 80.14 | -.3197E-02 | 0.0 | 0.0 |
| .58910 | 1.4352 | .89070E-01 | 41.97 | 241.41 | 245.03 | 0.240 | -0.00 | 80.14 | -.2767E-02 | 0.0 | 0.0 |
| .67819 | 1.4352 | .17815 | 42.01 | 241.41 | 245.04 | 0.240 | -0.02 | 80.13 | -.1[illegible]54E-02 | 0.0 | 0.0 |
| .76727 | 1.4352 | .26725 | 42.05 | 241.41 | 245.05 | 0.240 | -0.02 | 80.12 | -.4971E-03 | 0.0 | 0.0 |
| .85637 | 1.4351 | .35634 | 42.09 | 241.42 | 245.06 | 0.240 | -0.02 | 80.11 | .1615E-02 | 0.0 | 0.0 |
| .94545 | 1.4351 | .44542 | 42.13 | 241.42 | 245.07 | 0.240 | -0.01 | 80.10 | .4615E-02 | 0.0 | 0.0 |
| 1.0345 | 1.4351 | .53444 | 42.20 | 241.42 | 245.08 | 0.240 | 0.03 | 80.09 | .3995E-02 | 0.0 | 0.0 |
| 1.1234 | 1.4352 | .62341 | 42.29 | 241.41 | 245.09 | 0.240 | 0.04 | 80.05 | -.1147E-01 | 0.0 | 0.0 |
| 1.2126 | 1.4351 | .71257 | 42.30 | 241.42 | 245.09 | 0.240 | -0.07 | 80.06 | -.2260E-01 | 0.0 | 0.0 |
| 1.3021 | 1.4349 | .80209 | 42.06 | 241.46 | 245.10 | 0.240 | -0.20 | 80.12 | .2903E-01 | 0.0 | 0.0 |
| 1.3913 | 1.4348 | .89125 | 41.77 | 241.47 | 245.06 | 0.240 | 0.19 | 80.19 | .5814E-01 | 0.0 | 0.0 |
| 1.4793 | 1.4356 | .97930 | 41.68 | 241.33 | 244.91 | 0.240 | 0.30 | 80.20 | .7536E-01 | 0.0 | 0.0 |
| 1.5677 | 1.4368 | 1.0677 | 40.79 | 241.14 | 244.60 | 0.240 | 0.59 | 80.35 | -.6739E-01 | 0.0 | 0.0 |
| 1.6582 | 1.4373 | 1.1582 | 38.11 | 241.06 | 244.06 | 0.239 | 0.15 | 81.02 | .1759 | 0.0 | 0.0 |
| 1.7486 | 1.4390 | 1.2436 | 32.89 | 240.76 | 243.00 | 0.238 | 2.62 | 82.22 | .9119 | 0.0 | 0.0 |
| 1.8337 | 1.4473 | 1.3341 | 26.18 | 239.37 | 240.80 | 0.236 | 9.56 | 83.76 | 2.524 | 0.0 | 0.0 |
| 1.9025 | 1.4668 | 1.4056 | 20.90 | 236.18 | 237.10 | 0.232 | 23.95 | 84.94 | 5.199 | 0.0 | 0.0 |
| 1.9455 | 1.4942 | 1.4566 | 19.41 | 231.86 | 232.67 | 0.228 | 41.82 | 85.21 | 6.211 | 0.0 | 0.0 |
| 1.9753 | 1.5105 | 1.5035 | 21.05 | 226.36 | 227.33 | 0.223 | 58.79 | 84.69 | 5.445 | 0.0 | 0.0 |

** STREAMLINE NUMBER 21 — STREAM FUNCTION = 0.9500 **

| AXIAL COORD. (Z) | RADIAL COORD. (R) | MERID. COORD. (M) | MERID. VEL. (WM) | REL.TANG. VEL. (WTH) | REL. VEL. (W) | CRIT.VEL. RATIO (W/WCR) | MERID. ANGLE (ALPHA) | REL.FLOW ANGLE (BETA) | STREAM. CURV. (1./DIST) | SUCT.SUR. VEL. (WS) | PRES.SUR. VEL. (WP) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .50003 | 1.7349 | .0 | 41.71 | 199.70 | 204.01 | 0.200 | -0.01 | 78.20 | .2550E-03 | 0.0 | 0.0 |
| .58909 | 1.7348 | .89063E-01 | 41.72 | 199.70 | 204.01 | 0.200 | -0.01 | 78.20 | .1042E-02 | 0.0 | 0.0 |
| .67816 | 1.7348 | .17814 | 41.70 | 199.70 | 204.01 | 0.200 | -0.00 | 78.21 | .2087E-02 | 0.0 | 0.0 |
| .76725 | 1.7348 | .26722 | 41.65 | 199.70 | 204.00 | 0.200 | 0.01 | 78.22 | .5699E-03 | 0.0 | 0.0 |
| .85637 | 1.7349 | .35635 | 41.58 | 199.70 | 203.98 | 0.200 | 0.00 | 78.24 | -.4040E-02 | 0.0 | 0.0 |
| .94553 | 1.7348 | .44550 | 41.53 | 199.70 | 203.98 | 0.200 | -0.04 | 78.25 | -.9581E-02 | 0.0 | 0.0 |
| 1.0345 | 1.7347 | .53449 | 41.53 | 199.71 | 203.99 | 0.200 | -0.04 | 78.25 | -.1054E-02 | 0.0 | 0.0 |
| 1.1232 | 1.7346 | .62316 | 41.57 | 199.73 | 204.01 | 0.200 | -0.05 | 78.24 | .2227E-01 | 0.0 | 0.0 |
| 1.2122 | 1.7347 | .71213 | 41.56 | 199.72 | 204.00 | 0.200 | 0.13 | 78.24 | .3750E-01 | 0.0 | 0.0 |
| 1.3023 | 1.7351 | .80230 | 41.44 | 199.68 | 203.93 | 0.200 | 0.34 | 78.28 | -.1582E-02 | 0.0 | 0.0 |
| 1.3925 | 1.7355 | .89249 | 41.37 | 199.63 | 203.87 | 0.200 | 0.12 | 78.29 | -.8515E-01 | 0.0 | 0.0 |
| 1.4301 | 1.7352 | .98011 | 41.91 | 199.66 | 204.01 | 0.200 | -0.52 | 78.15 | -.8868E-01 | 0.0 | 0.0 |
| 1.5658 | 1.7341 | 1.0657 | 43.76 | 199.79 | 204.52 | 0.200 | -0.73 | 77.65 | .1429 | 0.0 | 0.0 |
| 1.6531 | 1.7335 | 1.1531 | 47.66 | 199.80 | 205.41 | 0.201 | 0.90 | 76.58 | .5371 | 0.0 | 0.0 |
| 1.7335 | 1.7376 | 1.2336 | 55.16 | 199.38 | 206.67 | 0.203 | 4.54 | 74.53 | 2.024 | 0.0 | 0.0 |
| 1.7351 | 1.7448 | 1.2857 | 67.03 | 198.55 | 209.56 | 0.205 | 12.75 | 71.35 | 5.770 | 0.0 | 0.0 |
| 1.4178 | 1.7522 | 1.3095 | 74.96 | 197.72 | 211.45 | 0.207 | 22.30 | 69.24 | 7.696 | 0.0 | 0.0 |
| 1.8169 | 1.7564 | 1.3195 | 77.69 | 197.24 | 211.99 | 0.208 | 26.77 | 68.50 | 7.927 | 0.0 | 0.0 |
| 1.8229 | 1.7597 | 1.3264 | 79.28 | 196.87 | 212.24 | 0.208 | 29.86 | 68.06 | 7.826 | 0.0 | 0.0 |
| 1.3309 | 1.7647 | 1.3359 | 81.15 | 196.31 | 212.42 | 0.208 | 33.98 | 67.54 | 7.528 | 0.0 | 0.0 |
| 1.8450 | 1.7756 | 1.3537 | 84.08 | 195.10 | 212.45 | 0.208 | 41.31 | 66.69 | 6.761 | 0.0 | 0.0 |
| 1.4692 | 1.8022 | 1.3876 | 90.02 | 192.22 | 212.25 | 0.208 | 53.43 | 64.91 | 5.243 | 0.0 | 0.0 |
| 1.9034 | 1.8594 | 1.4548 | 103.53 | 186.31 | 213.14 | 0.209 | 68.57 | 60.94 | 3.724 | 0.0 | 0.0 |
| 1.9186 | 1.9450 | 1.5423 | 109.03 | 178.10 | 209.33 | 0.205 | 83.80 | 58.53 | 1.872 | 0.0 | 0.0 |
| 1.9229 | 2.0321 | 1.6295 | 102.22 | 170.47 | 198.77 | 0.195 | 89.09 | 59.05 | .6190 | 0.0 | 0.0 |
| 1.9235 | 2.1176 | 1.7150 | 96.90 | 163.59 | 190.13 | 0.186 | 90.14 | 59.36 | .1607 | 0.0 | 0.0 |
| 1.9227 | 2.2051 | 1.8025 | 91.38 | 157.10 | 181.74 | 0.178 | 90.72 | 59.81 | .2275E-01 | 0.0 | 0.0 |
| 1.9218 | 2.2945 | 1.8919 | 86.88 | 150.98 | 174.19 | 0.171 | 90.35 | 60.08 | -.7705E-01 | 0.0 | 0.0 |
| 1.9216 | 2.3846 | 1.9820 | 83.60 | 145.28 | 167.61 | 0.164 | 89.93 | 60.08 | -.8026E-01 | 0.0 | 0.0 |
| 1.9221 | 2.4747 | 2.0721 | 79.86 | 139.98 | 161.16 | 0.158 | 89.52 | 60.30 | -.7844E-01 | 0.0 | 0.0 |

** STREAMLINE NUMBER 22 — STREAM FUNCTION = 1.0000 **

| AXIAL COORD. (Z) | RADIAL COORD. (R) | MERID. COORD. (M) | MERID. VEL. (WM) | REL.TANG. VEL. (WTH) | REL. VEL. (W) | CRIT.VEL. RATIO (W/WCR) | MERID. ANGLE (ALPHA) | REL.FLOW ANGLE (BETA) | STREAM. CURV. (1./DIST) | SUCT.SUR. VEL. (WS) | PRES.SUR. VEL. (WP) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .50003 | 1.7500 | .0 | 41.65 | 197.95 | 202.29 | 0.198 | -0.02 | 78.12 | .1958E-02 | 0.0 | 0.0 |
| .58909 | 1.7500 | .89060E-01 | 41.66 | 197.96 | 202.29 | 0.198 | -0.01 | 78.11 | .2653E-02 | 0.0 | 0.0 |
| .67816 | 1.7500 | .17813 | 41.63 | 197.96 | 202.29 | 0.198 | 0.01 | 78.12 | .3277E-02 | 0.0 | 0.0 |
| .76724 | 1.7500 | .26721 | 41.58 | 197.95 | 202.27 | 0.198 | 0.03 | 78.14 | .1070E-02 | 0.0 | 0.0 |
| .85637 | 1.7500 | .35634 | 41.51 | 197.95 | 202.25 | 0.198 | 0.02 | 78.15 | -.5250E-02 | 0.0 | 0.0 |
| .94554 | 1.7500 | .44550 | 41.45 | 197.95 | 202.24 | 0.198 | -0.03 | 78.17 | -.1130E-01 | 0.0 | 0.0 |
| 1.0345 | 1.7499 | .53452 | 41.45 | 197.96 | 202.25 | 0.198 | -0.10 | 78.18 | -.2433E-02 | 0.0 | 0.0 |
| 1.1232 | 1.7498 | .62317 | 41.49 | 197.98 | 202.28 | 0.198 | -0.05 | 78.16 | .2386E-01 | 0.0 | 0.0 |
| 1.2121 | 1.7499 | .71209 | 41.49 | 197.97 | 202.27 | 0.198 | 0.15 | 78.16 | .4207E-01 | 0.0 | 0.0 |
| 1.3022 | 1.7503 | .80221 | 41.34 | 197.92 | 202.19 | 0.198 | 0.38 | 78.20 | -.6127E-02 | 0.0 | 0.0 |
| 1.3925 | 1.7508 | .89249 | 41.24 | 197.87 | 202.12 | 0.198 | 0.08 | 78.23 | -.1128 | 0.0 | 0.0 |
| 1.4403 | 1.7503 | .98031 | 41.78 | 197.72 | 202.28 | 0.198 | -0.76 | 78.08 | -.1433 | 0.0 | 0.0 |
| 1.5661 | 1.7485 | 1.0661 | 43.77 | 198.12 | 202.90 | 0.199 | -1.35 | 77.54 | .6108E-01 | 0.0 | 0.0 |
| 1.6531 | 1.7472 | 1.1531 | 47.56 | 199.23 | 203.99 | 0.200 | -0.12 | 76.40 | .4826 | 0.0 | 0.0 |
| 1.7329 | 1.7489 | 1.2329 | 56.12 | 199.08 | 205.87 | 0.202 | 3.07 | 74.18 | 1.828 | 0.0 | 0.0 |
| 1.7834 | 1.7538 | 1.2836 | 69.16 | 197.52 | 209.28 | 0.205 | 10.47 | 70.70 | 6.372 | 0.0 | 0.0 |
| 1.8049 | 1.7597 | 1.3059 | 77.69 | 196.86 | 211.64 | 0.207 | 20.77 | 68.46 | 8.629 | 0.0 | 0.0 |
| 1.8135 | 1.7634 | 1.3153 | 80.48 | 196.45 | 212.30 | 0.208 | 25.54 | 67.72 | 8.814 | 0.0 | 0.0 |
| 1.8192 | 1.7663 | 1.3218 | 82.08 | 196.12 | 212.60 | 0.208 | 28.74 | 67.29 | 8.636 | 0.0 | 0.0 |
| 1.8269 | 1.7709 | 1.3307 | 83.87 | 195.62 | 212.85 | 0.209 | 33.07 | 66.79 | 8.151 | 0.0 | 0.0 |
| 1.8404 | 1.7810 | 1.3475 | 86.67 | 194.50 | 212.94 | 0.209 | 40.44 | 65.98 | 7.176 | 0.0 | 0.0 |
| 1.8639 | 1.8062 | 1.3820 | 92.22 | 191.79 | 212.81 | 0.209 | 52.91 | 64.32 | 5.455 | 0.0 | 0.0 |
| 1.8951 | 1.8615 | 1.4454 | 105.17 | 186.10 | 213.77 | 0.210 | 66.95 | 60.52 | 3.756 | 0.0 | 0.0 |
| 1.9135 | 1.9455 | 1.5315 | 110.06 | 178.06 | 209.33 | 0.205 | 84.74 | 58.28 | 2.218 | 0.0 | 0.0 |
| 1.9176 | 2.0323 | 1.6183 | 102.43 | 170.46 | 198.87 | 0.195 | 88.80 | 59.00 | .5570 | 0.0 | 0.0 |
| 1.9182 | 2.1176 | 1.7036 | 97.01 | 163.59 | 190.19 | 0.186 | 90.28 | 59.33 | .1992 | 0.0 | 0.0 |
| 1.9173 | 2.2050 | 1.7911 | 91.43 | 157.10 | 181.77 | 0.178 | 90.75 | 59.80 | .1099E-01 | 0.0 | 0.0 |
| 1.9163 | 2.2945 | 1.8806 | 86.68 | 150.98 | 174.19 | 0.171 | 90.37 | 60.08 | -.7967E-01 | 0.0 | 0.0 |
| 1.9161 | 2.3846 | 1.9706 | 83.59 | 145.28 | 167.61 | 0.164 | 89.93 | 60.08 | -.7650E-01 | 0.0 | 0.0 |
| 1.9165 | 2.4747 | 2.0608 | 79.12 | 139.98 | 160.79 | 0.158 | 89.58 | 60.52 | -.5915E-01 | 0.0 | 0.0 |

*** STREAM FUNCTION, INTERIOR VELOCITIES, VELOCITY COMPONENTS, ANGLES, AND SURFACE VELOCITIES ***
ALONG STREAMLINES

FULL MASSFLOW

ITERATION NO. 2

** STREAMLINE NUMBER 1 -- STREAM FUNCTION = 0.0 **

| AXIAL COORD. (Z) | RADIAL COORD. (R) | MERID. COORD. (M) | MERID. VEL. (WM) | REL.TANG. VEL. (WTH) | REL. VEL. (W) | CRIT.VEL. RATIO (W/WCR) | MERID. ANGLE (ALPHA) | REL.FLOW ANGLE (BETA) | STREAM. CURV. (1./DIST) | SUCT.SUR. VEL. (WS) | PRES.SUR. VEL. (WP) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .50000 | 1.4167 | .0 | 35.69 | 255.90 | 258.37 | 0.253 | 0.01 | 82.06 | -.9269E-03 | 0.0 | 0.0 |
| .59910 | 1.4167 | .89069E-01 | 35.69 | 255.89 | 258.37 | 0.253 | 0.00 | 82.06 | -.1364E-02 | 0.0 | 0.0 |
| .67818 | 1.4167 | .17815 | 35.73 | 255.89 | 258.38 | 0.253 | -0.00 | 82.05 | -.1375E-02 | 0.0 | 0.0 |
| .76727 | 1.4167 | .26724 | 35.78 | 255.90 | 258.39 | 0.253 | -0.01 | 82.04 | -.3773E-03 | 0.0 | 0.0 |
| .85637 | 1.4166 | .35634 | 35.84 | 255.90 | 258.40 | 0.253 | -0.01 | 82.03 | .1877E-02 | 0.0 | 0.0 |
| .94545 | 1.4166 | .44542 | 35.90 | 255.90 | 258.41 | 0.253 | 0.01 | 82.01 | .5978E-02 | 0.0 | 0.0 |
| 1.0345 | 1.4167 | .53445 | 35.98 | 255.89 | 258.41 | 0.253 | 0.03 | 82.00 | .4720E-02 | 0.0 | 0.0 |
| 1.1235 | 1.4168 | .62343 | 36.05 | 255.87 | 258.41 | 0.253 | 0.03 | 81.97 | -.1715E-01 | 0.0 | 0.0 |
| 1.2126 | 1.4168 | .71253 | 36.12 | 255.88 | 258.42 | 0.253 | -0.12 | 81.96 | -.3337E-01 | 0.0 | 0.0 |
| 1.3020 | 1.4164 | .80199 | 35.92 | 255.95 | 258.46 | 0.253 | -0.24 | 82.01 | .2525E-01 | 0.0 | 0.0 |
| 1.3913 | 1.4162 | .89127 | 35.67 | 255.98 | 258.46 | 0.253 | 0.13 | 82.07 | .1037 | 0.0 | 0.0 |
| 1.4796 | 1.4170 | .97955 | 35.65 | 255.84 | 258.31 | 0.253 | 0.77 | 82.07 | -.1147E-02 | 0.0 | 0.0 |
| 1.5678 | 1.4179 | 1.0678 | 35.12 | 255.68 | 258.08 | 0.253 | 0.12 | 82.19 | -.1932 | 0.0 | 0.0 |
| 1.6575 | 1.4168 | 1.1579 | 32.58 | 255.86 | 257.93 | 0.253 | -1.22 | 82.74 | -.5237E-01 | 0.0 | 0.0 |
| 1.7466 | 1.4152 | 1.2486 | 27.96 | 256.16 | 257.67 | 0.253 | -0.90 | 83.79 | .4869 | 0.0 | 0.0 |
| 1.8359 | 1.4170 | 1.3359 | 21.49 | 255.83 | 256.73 | 0.252 | 3.62 | 85.20 | 1.831 | 0.0 | 0.0 |
| 1.9133 | 1.4287 | 1.4142 | 15.58 | 253.74 | 254.22 | 0.249 | 15.71 | 86.49 | 4.898 | 0.0 | 0.0 |
| 1.9721 | 1.4590 | 1.4803 | 12.96 | 248.48 | 248.82 | 0.244 | 41.32 | 87.01 | 6.948 | 0.0 | 0.0 |
| 2.0066 | 1.5115 | 1.5443 | 14.62 | 239.84 | 240.29 | 0.236 | 67.47 | 86.51 | 5.665 | 0.0 | 0.0 |
| 2.0253 | 1.5835 | 1.6186 | 21.21 | 228.88 | 229.86 | 0.225 | 84.39 | 84.71 | 2.757 | 0.0 | 0.0 |
| 2.0276 | 1.6766 | 1.7053 | 34.20 | 217.00 | 219.67 | 0.215 | 91.05 | 81.04 | .7070 | 0.0 | 0.0 |
| 2.0252 | 1.7621 | 1.7969 | 53.21 | 205.73 | 212.50 | 0.208 | 91.20 | 75.50 | -.9057E-01 | 0.0 | 0.0 |
| 2.0242 | 1.8522 | 1.8870 | 72.54 | 195.72 | 208.73 | 0.205 | 90.12 | 69.67 | -.1660 | 0.0 | 0.0 |
| 2.0246 | 1.9409 | 1.9757 | 82.97 | 186.78 | 204.38 | 0.200 | 89.49 | 66.05 | -.7857E-01 | 0.0 | 0.0 |
| 2.0255 | 2.0290 | 2.0638 | 83.54 | 173.67 | 197.23 | 0.193 | 89.33 | 64.94 | .1153E-01 | 0.0 | 0.0 |
| 2.0264 | 2.1172 | 2.1520 | 80.18 | 171.22 | 189.07 | 0.185 | 89.61 | 64.91 | .6453E-01 | 0.0 | 0.0 |
| 2.0267 | 2.2060 | 2.2408 | 76.23 | 164.33 | 181.17 | 0.178 | 89.98 | 65.10 | .5553E-01 | 0.0 | 0.0 |
| 2.0265 | 2.2953 | 2.3300 | 72.90 | 157.94 | 173.95 | 0.170 | 90.22 | 65.22 | .3852E-01 | 0.0 | 0.0 |
| 2.0261 | 2.3848 | 2.4196 | 70.35 | 152.01 | 167.50 | 0.164 | 90.37 | 65.16 | .2617E-01 | 0.0 | 0.0 |
| 2.0254 | 2.4746 | 2.5094 | 68.62 | 146.50 | 161.77 | 0.159 | 90.49 | 64.90 | .1746E-01 | 0.0 | 0.0 |

** STREAMLINE NUMBER 2 -- STREAM FUNCTION = 0.0500 **

| AXIAL COORD. (Z) | RADIAL COORD. (R) | MERID. COORD. (M) | MERID. VEL. (WM) | REL.TANG. VEL. (WTH) | REL. VEL. (W) | CRIT.VEL. RATIO (W/WCR) | MERID. ANGLE (ALPHA) | REL.FLOW ANGLE (BETA) | STREAM. CURV. (1./DIST) | SUCT.SUR. VEL. (WS) | PRES.SUR. VEL. (WP) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .50000 | 1.4352 | .0 | 35.59 | 252.63 | 255.12 | 0.250 | 0.01 | 81.98 | -.3240E-02 | 0.0 | 0.0 |
| .59910 | 1.4352 | .89070E-01 | 35.59 | 252.63 | 255.12 | 0.250 | -0.00 | 81.98 | -.3173E-02 | 0.0 | 0.0 |
| .67818 | 1.4352 | .17815 | 35.63 | 252.63 | 255.13 | 0.250 | -0.02 | 81.97 | -.2419E-02 | 0.0 | 0.0 |
| .76727 | 1.4351 | .26725 | 35.67 | 252.64 | 255.15 | 0.250 | -0.03 | 81.96 | -.7151E-03 | 0.0 | 0.0 |
| .85637 | 1.4351 | .35634 | 35.73 | 252.65 | 255.16 | 0.250 | -0.03 | 81.95 | .1594E-02 | 0.0 | 0.0 |
| .94545 | 1.4350 | .44542 | 35.79 | 252.65 | 255.18 | 0.250 | -0.01 | 81.94 | .4782E-02 | 0.0 | 0.0 |
| 1.0345 | 1.4350 | .53444 | 35.86 | 252.65 | 255.18 | 0.250 | 0.02 | 81.92 | .4032E-02 | 0.0 | 0.0 |
| 1.1234 | 1.4351 | .62341 | 35.95 | 252.64 | 255.19 | 0.250 | 0.03 | 81.90 | -.1173E-01 | 0.0 | 0.0 |
| 1.2126 | 1.4351 | .71257 | 35.98 | 252.65 | 255.20 | 0.250 | -0.11 | 81.90 | -.2283E-01 | 0.0 | 0.0 |
| 1.3021 | 1.4348 | .80209 | 35.80 | 252.70 | 255.22 | 0.250 | -0.20 | 81.94 | .2318E-01 | 0.0 | 0.0 |
| 1.3913 | 1.4347 | .89125 | 35.57 | 252.71 | 255.20 | 0.250 | 0.19 | 81.99 | .9342E-01 | 0.0 | 0.0 |
| 1.4793 | 1.4355 | .97530 | 35.51 | 252.57 | 255.05 | 0.250 | 0.77 | 82.00 | .3881E-01 | 0.0 | 0.0 |
| 1.5677 | 1.4367 | 1.0677 | 34.94 | 252.37 | 254.78 | 0.250 | 0.53 | 82.12 | -.6878E-01 | 0.0 | 0.0 |
| 1.6582 | 1.4371 | 1.1582 | 32.51 | 252.29 | 254.38 | 0.249 | 0.13 | 82.66 | .1746 | 0.0 | 0.0 |
| 1.7486 | 1.4388 | 1.2486 | 28.08 | 251.99 | 253.55 | 0.249 | 2.57 | 83.64 | .9110 | 0.0 | 0.0 |
| 1.8337 | 1.4470 | 1.3341 | 22.39 | 250.55 | 251.54 | 0.247 | 9.53 | 84.90 | 2.535 | 0.0 | 0.0 |
| 1.9025 | 1.4666 | 1.4056 | 17.79 | 247.19 | 247.83 | 0.243 | 24.04 | 85.88 | 5.230 | 0.0 | 0.0 |
| 1.9456 | 1.4942 | 1.4568 | 16.49 | 242.64 | 243.20 | 0.238 | 42.00 | 86.11 | 6.216 | 0.0 | 0.0 |
| [illegible] | [illegible] | [illegible] | 17.86 | 236.87 | 237.54 | 0.233 | 54.93 | 85.69 | 5.419 | 0.0 | 0.0 |

** STREAMLINE NUMBER 21 -- STREAM FUNCTION = 0.9500 **

| AXIAL COORD. (Z) | RADIAL COORD. (R) | MERID. COORD. (M) | MERID. VEL. (WM) | REL.TANG. VEL. (WTH) | REL. VEL. (W) | CRIT.VEL. RATIO (W/WCR) | MERID. ANGLE (ALPHA) | REL.FLOW ANGLE (BETA) | STREAM. CURV. (1./DIST) | SUCT.SUR. VEL. (WS) | PRES.SUR. VEL. (WP) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .50003 | 1.7345 | .0 | 35.29 | 208.98 | 211.94 | 0.208 | -0.01 | 80.41 | -.5832E-03 | 0.0 | 0.0 |
| .53909 | 1.7348 | .89062E-01 | 35.30 | 208.98 | 211.94 | 0.208 | -0.01 | 80.41 | .4905E-03 | 0.0 | 0.0 |
| .67616 | 1.7348 | .17814 | 35.27 | 208.99 | 211.94 | 0.208 | -0.01 | 80.42 | .1652E-02 | 0.0 | 0.0 |
| .76725 | 1.7348 | .26722 | 35.21 | 208.99 | 211.93 | 0.208 | 0.01 | 80.44 | .5464E-03 | 0.0 | 0.0 |
| .85637 | 1.7348 | .35635 | 35.14 | 208.98 | 211.92 | 0.208 | -0.00 | 80.46 | -.4745E-02 | 0.0 | 0.0 |
| .94553 | 1.7348 | .44550 | 35.08 | 208.99 | 211.91 | 0.208 | -0.04 | 80.47 | -.9541E-02 | 0.0 | 0.0 |
| 1.0345 | 1.7347 | .53449 | 35.06 | 209.00 | 211.92 | 0.208 | -0.10 | 80.48 | -.9808E-03 | 0.0 | 0.0 |
| 1.1232 | 1.7346 | .62316 | 35.07 | 209.02 | 211.94 | 0.208 | -0.05 | 80.47 | .2220E-01 | 0.0 | 0.0 |
| 1.2122 | 1.7346 | .71213 | 35.05 | 209.01 | 211.93 | 0.208 | 0.15 | 80.48 | .3747E-01 | 0.0 | 0.0 |
| 1.3023 | 1.7350 | .80230 | 34.92 | 208.97 | 211.86 | 0.208 | 0.33 | 80.51 | -.1455E-02 | 0.0 | 0.0 |
| 1.3925 | 1.7354 | .89249 | 34.85 | 208.92 | 211.80 | 0.208 | 0.11 | 80.53 | -.8460E-01 | 0.0 | 0.0 |
| 1.4801 | 1.7351 | .98011 | 35.23 | 208.95 | 211.71 | 0.208 | -0.52 | 80.41 | -.8768E-01 | 0.0 | 0.0 |
| 1.5058 | 1.7340 | 1.0657 | 36.65 | 209.08 | 212.30 | 0.208 | -0.73 | 80.00 | .1445 | 0.0 | 0.0 |
| 1.6531 | 1.7335 | 1.1531 | 40.15 | 209.10 | 212.92 | 0.209 | 0.91 | 79.13 | .5899 | 0.0 | 0.0 |
| 1.7335 | 1.7376 | 1.2336 | 46.52 | 208.65 | 213.77 | 0.210 | 4.55 | 77.43 | 2.026 | 0.0 | 0.0 |
| 1.7651 | 1.7448 | 1.2657 | 56.61 | 207.78 | 215.35 | 0.211 | 12.77 | 74.76 | 5.768 | 0.0 | 0.0 |
| 1.8078 | 1.7522 | 1.3095 | 63.30 | 206.91 | 216.39 | 0.212 | 22.31 | 72.97 | 7.693 | 0.0 | 0.0 |
| 1.8169 | 1.7584 | 1.3195 | 65.69 | 206.41 | 216.61 | 0.212 | 26.77 | 72.35 | 7.923 | 0.0 | 0.0 |
| 1.8225 | 1.7597 | 1.3264 | 67.05 | 205.02 | 216.66 | 0.212 | 29.87 | 71.97 | 7.823 | 0.0 | 0.0 |
| 1.8309 | 1.7647 | 1.3359 | 68.65 | 205.44 | 216.60 | 0.212 | 34.00 | 71.52 | 7.526 | 0.0 | 0.0 |
| 1.8450 | 1.7756 | 1.3537 | 71.17 | 204.17 | 216.22 | 0.212 | 41.31 | 70.78 | 6.778 | 0.0 | 0.0 |
| 1.8692 | 1.8022 | 1.3896 | 76.24 | 201.15 | 215.12 | 0.211 | 53.44 | 69.24 | 5.242 | 0.0 | 0.0 |
| 1.9004 | 1.8594 | 1.4548 | 87.67 | 194.96 | 213.77 | 0.210 | 68.57 | 65.79 | 3.723 | 0.0 | 0.0 |
| 1.9186 | 1.9450 | 1.5423 | 92.29 | 185.38 | 207.98 | 0.204 | 83.80 | 63.66 | 1.873 | 0.0 | 0.0 |
| 1.9229 | 2.0321 | 1.6295 | 86.51 | 173.39 | 198.26 | 0.194 | 89.09 | 64.13 | .6191 | 0.0 | 0.0 |
| 1.9235 | 2.1176 | 1.7150 | 82.01 | 171.19 | 189.82 | 0.186 | 90.14 | 64.40 | .1668 | 0.0 | 0.0 |
| 1.9227 | 2.2051 | 1.8025 | 77.35 | 164.40 | 181.69 | 0.178 | 90.72 | 64.80 | .2272E-01 | 0.0 | 0.0 |
| 1.9218 | 2.2945 | 1.8519 | 73.54 | 157.99 | 174.27 | 0.171 | 90.35 | 65.04 | -.7706E-01 | 0.0 | 0.0 |
| 1.9216 | 2.3846 | 1.9820 | 70.76 | 152.03 | 167.69 | 0.164 | 89.93 | 65.04 | -.8025E-01 | 0.0 | 0.0 |
| 1.9221 | 2.4747 | 2.0721 | 67.60 | 146.49 | 161.33 | 0.158 | 89.52 | 65.23 | -.7838E-01 | 0.0 | 0.0 |

** STREAMLINE NUMBER 22 -- STREAM FUNCTION = 1.0000 **

| AXIAL COORD. (Z) | RADIAL COORD. (R) | MERID. COORD. (M) | MERID. VEL. (WM) | REL.TANG. VEL. (WTH) | REL. VEL. (W) | CRIT.VEL. RATIO (W/WCR) | MERID. ANGLE (ALPHA) | REL.FLOW ANGLE (BETA) | STREAM. CURV. (1./DIST) | SUCT.SUR. VEL. (WS) | PRES.SUR. VEL. (WP) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .50003 | 1.7500 | .0 | 35.24 | 207.15 | 210.13 | 0.206 | -0.02 | 80.35 | .1958E-02 | 0.0 | 0.0 |
| .53909 | 1.7500 | .89060E-01 | 35.25 | 207.16 | 210.13 | 0.206 | -0.01 | 80.34 | .2653E-02 | 0.0 | 0.0 |
| .67616 | 1.7500 | .17813 | 35.21 | 207.16 | 210.13 | 0.206 | 0.01 | 80.35 | .3277E-02 | 0.0 | 0.0 |
| .76724 | 1.7500 | .26721 | 35.15 | 207.15 | 210.11 | 0.206 | 0.03 | 80.37 | .1070E-02 | 0.0 | 0.0 |
| .85637 | 1.7500 | .35634 | 35.07 | 207.15 | 210.10 | 0.206 | 0.02 | 80.39 | -.5250E-02 | 0.0 | 0.0 |
| .94554 | 1.7500 | .44550 | 35.00 | 207.15 | 210.08 | 0.206 | -0.03 | 80.41 | -.1150E-01 | 0.0 | 0.0 |
| 1.0345 | 1.7499 | .53452 | 34.98 | 207.16 | 210.09 | 0.206 | -0.10 | 80.42 | -.2493E-02 | 0.0 | 0.0 |
| 1.1232 | 1.7498 | .62317 | 35.00 | 207.18 | 210.11 | 0.206 | -0.05 | 80.41 | .2346E-01 | 0.0 | 0.0 |
| 1.2121 | 1.7495 | .71209 | 34.98 | 207.17 | 210.10 | 0.206 | 0.15 | 80.42 | .4209E-01 | 0.0 | 0.0 |
| 1.3022 | 1.7503 | .80221 | 34.83 | 207.12 | 210.03 | 0.206 | 0.33 | 80.45 | -.6127E-02 | 0.0 | 0.0 |
| 1.3925 | 1.7508 | .89248 | 34.73 | 207.07 | 209.96 | 0.206 | 0.08 | 80.48 | -.1128 | 0.0 | 0.0 |
| 1.4803 | 1.7503 | .98031 | 35.17 | 207.12 | 210.08 | 0.206 | -0.76 | 80.36 | -.1438 | 0.0 | 0.0 |
| 1.5661 | 1.7485 | 1.0661 | 36.64 | 207.33 | 210.58 | 0.206 | -1.35 | 79.92 | .6108E-01 | 0.0 | 0.0 |
| 1.6531 | 1.7472 | 1.1531 | 40.39 | 207.49 | 211.39 | 0.207 | -0.12 | 78.99 | .4826 | 0.0 | 0.0 |
| 1.7329 | 1.7489 | 1.2329 | 47.33 | 207.28 | 212.62 | 0.208 | 3.07 | 77.14 | 1.828 | 0.0 | 0.0 |
| 1.7834 | 1.7538 | 1.2836 | 58.40 | 206.70 | 214.80 | 0.211 | 13.47 | 74.22 | 6.372 | 0.0 | 0.0 |
| 1.8049 | 1.7557 | 1.3059 | 65.05 | 205.01 | 215.22 | 0.212 | 20.77 | 72.32 | 8.629 | 0.0 | 0.0 |
| 1.8135 | 1.7634 | 1.3153 | 68.05 | 205.53 | 216.55 | 0.212 | 25.54 | 71.68 | 8.814 | 0.0 | 0.0 |
| 1.8192 | 1.7663 | 1.3218 | 69.41 | 205.24 | 215.66 | 0.212 | 28.78 | 71.31 | 8.836 | 0.0 | 0.0 |
| 1.8269 | 1.7709 | 1.3307 | 70.97 | 204.71 | 216.66 | 0.212 | 33.00 | 70.88 | 8.151 | 0.0 | 0.0 |
| 1.8404 | 1.7810 | 1.3475 | 73.35 | 203.54 | 216.36 | 0.212 | 40.44 | 70.18 | 7.176 | 0.0 | 0.0 |
| 1.8635 | 1.8062 | 1.3820 | 78.10 | 200.70 | 215.36 | 0.211 | 52.91 | 68.74 | 5.455 | 0.0 | 0.0 |
| 1.8951 | 1.8615 | 1.4454 | 89.09 | 194.75 | 214.16 | 0.210 | 66.95 | 65.42 | 3.756 | 0.0 | 0.0 |
| 1.9135 | 1.9455 | 1.5315 | 93.17 | 186.34 | 208.33 | 0.204 | 84.74 | 63.44 | 2.218 | 0.0 | 0.0 |
| 1.9176 | 2.0323 | 1.6183 | 86.70 | 178.38 | 198.33 | 0.194 | 88.80 | 64.08 | .5570 | 0.0 | 0.0 |
| 1.9182 | 2.1176 | 1.7036 | 82.12 | 171.19 | 189.87 | 0.186 | 90.28 | 64.37 | .1992 | 0.0 | 0.0 |
| 1.9173 | 2.2050 | 1.7911 | 77.39 | 164.41 | 181.71 | 0.178 | 90.75 | 64.79 | .1059E-01 | 0.0 | 0.0 |
| 1.9163 | 2.2945 | 1.8806 | 73.55 | 158.00 | 174.28 | 0.171 | 90.37 | 65.04 | -.7967E-01 | 0.0 | 0.0 |
| 1.9161 | 2.3846 | 1.9706 | 70.76 | 152.03 | 167.69 | 0.164 | 89.93 | 65.04 | -.7650E-01 | 0.0 | 0.0 |
| 1.9165 | 2.4747 | 2.0608 | 66.98 | 146.49 | 161.07 | 0.158 | 89.58 | 65.43 | -.5915E-01 | 0.0 | 0.0 |

*** STREAM FUNCTION, INTERIOR VELOCITIES, VELOCITY COMPONENTS, ANGLES, AND SURFACE VELOCITIES ***
ALONG STREAMLINES

* FULL MASSFLOW *
* ITERATION NO. 2 *

** STREAMLINE NUMBER 1 — STREAM FUNCTION = 0.0 **

| AXIAL COORD. (Z) | RADIAL COORD. (R) | MERID. COORD. (M) | MERID. VEL. (WM) | REL.TANG. VEL. (WTH) | REL. VEL. (W) | CRIT.VEL. RATIO (W/WCR) | MERID. ANGLE (ALPHA) | REL.FLOW ANGLE (BETA) | STREAM. CURV. (1./DIST) | SUCT.SUR. VEL. (WS) | PRES.SUR. VEL. (WP) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .50003 | 1.4167 | .0 | 28.98 | 265.33 | 266.90 | 0.262 | 0.01 | 83.77 | -.9259E-03 | 0.0 | 0.0 |
| .58910 | 1.4167 | .89069E-01 | 28.98 | 265.32 | 266.90 | 0.262 | 0.00 | 83.77 | -.1364E-02 | 0.0 | 0.0 |
| .67818 | 1.4167 | .17815 | 29.03 | 265.32 | 266.91 | 0.262 | -0.00 | 83.76 | -.1375E-02 | 0.0 | 0.0 |
| .76727 | 1.4167 | .26724 | 29.10 | 265.33 | 266.92 | 0.262 | -0.01 | 83.74 | -.3773E-03 | 0.0 | 0.0 |
| .85637 | 1.4166 | .35634 | 29.18 | 265.33 | 266.93 | 0.262 | -0.01 | 83.72 | .1877E-02 | 0.0 | 0.0 |
| .94545 | 1.4166 | .44542 | 29.26 | 265.33 | 266.94 | 0.262 | 0.01 | 83.71 | .5978E-02 | 0.0 | 0.0 |
| 1.0345 | 1.4167 | .53445 | 29.35 | 265.32 | 266.94 | 0.262 | 0.05 | 83.69 | .4720E-02 | 0.0 | 0.0 |
| 1.1235 | 1.4166 | .62343 | 29.47 | 265.30 | 266.93 | 0.262 | 0.05 | 83.66 | -.1715E-01 | 0.0 | 0.0 |
| 1.2126 | 1.4168 | .71253 | 29.52 | 265.31 | 266.95 | 0.262 | -0.12 | 83.65 | -.3337E-01 | 0.0 | 0.0 |
| 1.3020 | 1.4164 | .80199 | 29.40 | 265.36 | 267.00 | 0.262 | -0.28 | 83.68 | .2526E-01 | 0.0 | 0.0 |
| 1.3913 | 1.4162 | .89127 | 29.22 | 265.42 | 267.02 | 0.262 | 0.13 | 83.72 | .1037 | 0.0 | 0.0 |
| 1.4796 | 1.4170 | .97955 | 29.23 | 265.27 | 266.87 | 0.262 | 0.77 | 83.71 | -.1147E-02 | 0.0 | 0.0 |
| 1.5678 | 1.4175 | 1.0678 | 28.82 | 265.11 | 266.67 | 0.261 | 0.12 | 83.80 | -.1932 | 0.0 | 0.0 |
| 1.6575 | 1.4168 | 1.1579 | 26.78 | 265.29 | 266.64 | 0.261 | -1.22 | 84.24 | -.5237E-01 | 0.0 | 0.0 |
| 1.7466 | 1.4152 | 1.2486 | 22.94 | 265.60 | 266.59 | 0.261 | -0.40 | 85.06 | .4869 | 0.0 | 0.0 |
| 1.8355 | 1.4170 | 1.3359 | 17.72 | 265.26 | 265.85 | 0.261 | 3.62 | 86.19 | 1.801 | 0.0 | 0.0 |
| 1.9133 | 1.4267 | 1.4142 | 12.82 | 263.09 | 263.40 | 0.258 | 15.71 | 87.21 | 4.898 | 0.0 | 0.0 |
| 1.9721 | 1.4590 | 1.4803 | 10.56 | 257.64 | 257.85 | 0.253 | 41.32 | 87.65 | 6.948 | 0.0 | 0.0 |
| 2.0086 | 1.5115 | 1.5443 | 11.75 | 248.63 | 248.96 | 0.244 | 67.47 | 87.29 | 5.665 | 0.0 | 0.0 |
| 2.0253 | 1.5835 | 1.6186 | 16.94 | 237.31 | 237.92 | 0.233 | 84.34 | 85.92 | 2.757 | 0.0 | 0.0 |
| 2.0276 | 1.6706 | 1.7053 | 27.33 | 224.99 | 226.65 | 0.222 | 91.05 | 83.06 | .7070 | 0.0 | 0.0 |
| 2.0252 | 1.7621 | 1.7969 | 42.79 | 213.31 | 217.56 | 0.213 | 91.20 | 78.66 | -.5057E-01 | 0.0 | 0.0 |
| 2.0242 | 1.8522 | 1.8870 | 58.49 | 202.94 | 211.20 | 0.207 | 90.12 | 73.92 | -.1660 | 0.0 | 0.0 |
| 2.0246 | 1.9409 | 1.9757 | 66.97 | 193.66 | 204.91 | 0.201 | 89.49 | 70.92 | -.7857E-01 | 0.0 | 0.0 |
| 2.0255 | 2.0290 | 2.0638 | 67.44 | 185.25 | 197.14 | 0.193 | 89.33 | 70.00 | .1153E-01 | 0.0 | 0.0 |
| 2.0264 | 2.1172 | 2.1520 | 64.73 | 177.53 | 188.96 | 0.185 | 89.61 | 69.97 | .6453E-01 | 0.0 | 0.0 |
| 2.0267 | 2.2060 | 2.2408 | 61.58 | 173.39 | 181.17 | 0.178 | 89.93 | 70.13 | .5553E-01 | 0.0 | 0.0 |
| 2.0265 | 2.2953 | 2.3300 | 58.85 | 163.76 | 174.01 | 0.171 | 90.22 | 70.23 | .3852E-01 | 0.0 | 0.0 |
| 2.0261 | 2.3848 | 2.4196 | 56.80 | 157.61 | 167.53 | 0.164 | 90.37 | 70.18 | .2617E-01 | 0.0 | 0.0 |
| 2.0254 | 2.4746 | 2.5094 | 55.39 | 151.90 | 161.68 | 0.158 | 90.49 | 69.96 | .1746E-01 | 0.0 | 0.0 |

** STREAMLINE NUMBER 2 — STREAM FUNCTION = 0.0500 **

| AXIAL COORD. (Z) | RADIAL COORD. (R) | MERID. COORD. (M) | MERID. VEL. (WM) | REL.TANG. VEL. (WTH) | REL. VEL. (W) | CRIT.VEL. RATIO (W/WCR) | MERID. ANGLE (ALPHA) | REL.FLOW ANGLE (BETA) | STREAM. CURV. (1./DIST) | SUCT.SUR. VEL. (WS) | PRES.SUR. VEL. (WP) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .50003 | 1.4351 | .0 | 28.90 | 261.95 | 263.53 | 0.258 | 0.02 | 83.70 | -.4484E-02 | 0.0 | 0.0 |
| .58910 | 1.4352 | .89070E-01 | 28.93 | 261.94 | 263.53 | 0.258 | -0.01 | 83.70 | -.4220E-02 | 0.0 | 0.0 |
| .67818 | 1.4351 | .17815 | 28.94 | 261.95 | 263.54 | 0.258 | -0.03 | 83.70 | -.3082E-02 | 0.0 | 0.0 |
| .76727 | 1.4351 | .26725 | 29.00 | 261.96 | 263.56 | 0.258 | -0.04 | 83.68 | -.9700E-03 | 0.0 | 0.0 |
| .85637 | 1.4350 | .35634 | 29.07 | 261.97 | 263.58 | 0.258 | -0.04 | 83.67 | .1552E-02 | 0.0 | 0.0 |
| .94545 | 1.4350 | .44542 | 29.15 | 261.98 | 263.60 | 0.258 | -0.02 | 83.65 | .4787E-02 | 0.0 | 0.0 |
| 1.0345 | 1.4349 | .53444 | 29.23 | 261.98 | 263.61 | 0.259 | 0.01 | 83.63 | .4035E-02 | 0.0 | 0.0 |
| 1.1234 | 1.4350 | .62341 | 29.34 | 261.98 | 263.61 | 0.258 | 0.02 | 83.61 | -.1183E-01 | 0.0 | 0.0 |
| 1.2126 | 1.4349 | .71257 | 29.36 | 261.99 | 263.63 | 0.258 | -0.11 | 83.60 | -.2302E-01 | 0.0 | 0.0 |
| 1.3021 | 1.4346 | .80209 | 29.27 | 262.04 | 263.67 | 0.258 | -0.22 | 83.63 | .2832E-01 | 0.0 | 0.0 |
| 1.3913 | 1.4345 | .89125 | 29.11 | 262.06 | 263.67 | 0.258 | 0.13 | 83.66 | .9879E-01 | 0.0 | 0.0 |
| 1.4793 | 1.4353 | .97931 | 29.04 | 261.91 | 263.52 | 0.258 | 0.74 | 83.66 | .3816E-01 | 0.0 | 0.0 |
| 1.5677 | 1.4364 | 1.0677 | 28.64 | 261.71 | 263.27 | 0.258 | 0.56 | 83.75 | -.7102E-01 | 0.0 | 0.0 |
| 1.6582 | 1.4368 | 1.1582 | 26.68 | 261.64 | 262.99 | 0.258 | 0.09 | 84.18 | .1711 | 0.0 | 0.0 |
| 1.7486 | 1.4385 | 1.2486 | 23.05 | 261.34 | 262.35 | 0.257 | 2.51 | 84.96 | .9036 | 0.0 | 0.0 |
| 1.8338 | 1.4466 | 1.3341 | 18.34 | 259.86 | 260.51 | 0.255 | 9.46 | 85.96 | 2.550 | 0.0 | 0.0 |
| 1.9026 | 1.4682 | 1.4058 | 14.53 | 256.37 | 256.78 | 0.252 | 24.16 | 86.76 | 5.291 | 0.0 | 0.0 |
| 1.9437 | 1.4940 | 1.4570 | 13.43 | 251.61 | 251.97 | 0.247 | 42.34 | 86.95 | 6.231 | 0.0 | 0.0 |
| 1.9752 | 1.5306 | 1.5040 | 14.51 | 245.59 | 246.02 | 0.241 | 59.19 | 86.62 | 5.308 | 0.0 | 0.0 |
| 1.9688 | [illegible] | 1.5666 | 18.66 | 236.61 | 237.15 | 0.233 | 75.16 | 85.49 | 3.474 | [illegible] | 0.0 |

** STREAMLINE NUMBER 21 -- STREAM FUNCTION = 0.9500 **

| AXIAL COORD. (Z) | RADIAL COORD. (R) | MERID. COORD. (M) | MERID. VEL. (WM) | REL.TANG. VEL. (WTH) | REL. VEL. (W) | CRIT.VEL. RATIO (W/WCR) | MERID. ANGLE (ALPHA) | REL.FLOW ANGLE (BETA) | STREAM. CURV. (1./DIST) | SUCT.SUR. VEL. (WS) | PRES.SUR. VEL. (WP) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .50003 | 1.7348 | .0 | 28.56 | 216.69 | 219.56 | 0.214 | -0.01 | 82.49 | -.1758E-02 | 0.0 | 0.0 |
| .58909 | 1.7348 | .89053E-01 | 28.57 | 216.69 | 218.56 | 0.214 | -0.01 | 82.49 | -.4334E-03 | 0.0 | 0.0 |
| .67616 | 1.7348 | .17814 | 28.53 | 216.69 | 218.56 | 0.214 | -0.01 | 82.50 | .1371E-02 | 0.0 | 0.0 |
| .76725 | 1.7348 | .26722 | 28.46 | 216.69 | 218.55 | 0.214 | -0.00 | 82.52 | .3572E-03 | 0.0 | 0.0 |
| .85638 | 1.7348 | .35635 | 28.38 | 216.69 | 218.54 | 0.214 | -0.01 | 82.54 | -.4864E-02 | 0.0 | 0.0 |
| .94553 | 1.7347 | .44550 | 28.30 | 216.70 | 218.54 | 0.214 | -0.05 | 82.56 | -.9550E-02 | 0.0 | 0.0 |
| 1.0345 | 1.7346 | .53450 | 28.26 | 216.71 | 218.55 | 0.214 | -0.11 | 82.57 | -.9443E-03 | 0.0 | 0.0 |
| 1.1232 | 1.7345 | .62317 | 28.24 | 216.73 | 218.57 | 0.214 | -0.06 | 82.58 | .2216E-01 | 0.0 | 0.0 |
| 1.2122 | 1.7345 | .71213 | 28.20 | 216.73 | 218.56 | 0.214 | 0.12 | 82.59 | .3743E-01 | 0.0 | 0.0 |
| 1.3023 | 1.7349 | .80230 | 28.07 | 216.68 | 218.49 | 0.214 | 0.32 | 82.62 | -.1274E-02 | 0.0 | 0.0 |
| 1.3925 | 1.7353 | .89249 | 27.99 | 216.63 | 218.43 | 0.214 | 0.11 | 82.64 | -.6415E-01 | 0.0 | 0.0 |
| 1.4801 | 1.7350 | .98011 | 28.32 | 216.67 | 218.51 | 0.214 | -0.52 | 82.55 | -.6593E-01 | 0.0 | 0.0 |
| 1.5658 | 1.7339 | 1.0657 | 29.57 | 216.81 | 218.81 | 0.214 | -0.77 | 82.23 | .1471 | 0.0 | 0.0 |
| 1.6531 | 1.7338 | 1.1531 | 32.25 | 216.82 | 219.20 | 0.215 | 0.93 | 81.54 | .5924 | 0.0 | 0.0 |
| 1.7335 | 1.7375 | 1.2336 | 37.45 | 216.35 | 219.56 | 0.215 | 4.60 | 80.18 | 2.029 | 0.0 | 0.0 |
| 1.7852 | 1.7448 | 1.2857 | 45.68 | 215.44 | 220.23 | 0.216 | 12.81 | 78.03 | 5.763 | 0.0 | 0.0 |
| 1.8078 | 1.7521 | 1.3095 | 51.22 | 214.54 | 220.56 | 0.216 | 22.34 | 76.57 | 7.686 | 0.0 | 0.0 |
| 1.8169 | 1.7564 | 1.3195 | 53.13 | 214.02 | 220.52 | 0.216 | 26.81 | 76.06 | 7.918 | 0.0 | 0.0 |
| 1.8229 | 1.7597 | 1.3264 | 54.26 | 213.62 | 220.40 | 0.216 | 29.90 | 75.75 | 7.618 | 0.0 | 0.0 |
| 1.8309 | 1.7647 | 1.3359 | 55.59 | 213.01 | 220.14 | 0.216 | 34.02 | 75.37 | 7.521 | 0.0 | 0.0 |
| 1.8450 | 1.7756 | 1.3537 | 57.68 | 211.70 | 219.41 | 0.215 | 41.33 | 74.76 | 6.773 | 0.0 | 0.0 |
| 1.8692 | 1.8023 | 1.3897 | 61.87 | 208.56 | 217.55 | 0.213 | 53.44 | 73.48 | 5.238 | 0.0 | 0.0 |
| 1.9004 | 1.8554 | 1.4548 | 71.17 | 202.15 | 214.31 | 0.210 | 68.55 | 70.60 | 3.721 | 0.0 | 0.0 |
| 1.9166 | 1.9450 | 1.5423 | 74.87 | 193.25 | 207.25 | 0.203 | 83.80 | 68.82 | 1.874 | 0.0 | 0.0 |
| 1.9229 | 2.0321 | 1.6295 | 70.17 | 184.97 | 197.83 | 0.194 | 89.09 | 69.22 | .6191 | 0.0 | 0.0 |
| 1.9235 | 2.1176 | 1.7150 | 66.52 | 177.50 | 189.56 | 0.186 | 90.14 | 69.45 | .1669 | 0.0 | 0.0 |
| 1.9227 | 2.2051 | 1.8025 | 62.75 | 170.46 | 181.64 | 0.178 | 90.72 | 69.79 | .2266E-01 | 0.0 | 0.0 |
| 1.9218 | 2.2945 | 1.8919 | 59.66 | 163.81 | 174.34 | 0.171 | 90.35 | 69.99 | -.7709E-01 | 0.0 | 0.0 |
| 1.9216 | 2.3846 | 1.9820 | 57.40 | 157.63 | 167.76 | 0.164 | 89.93 | 69.99 | -.6022E-01 | 0.0 | 0.0 |
| 1.9220 | 2.4747 | 2.0721 | 54.84 | 151.89 | 161.48 | 0.158 | 89.52 | 70.15 | -.7830E-01 | 0.0 | 0.0 |

** STREAMLINE NUMBER 22 -- STREAM FUNCTION = 1.0000 **

| AXIAL COORD. (Z) | RADIAL COORD. (R) | MERID. COORD. (M) | MERID. VEL. (WM) | REL.TANG. VEL. (WTH) | REL. VEL. (W) | CRIT.VEL. RATIO (W/WCR) | MERID. ANGLE (ALPHA) | REL.FLOW ANGLE (BETA) | STREAM. CURV. (1./DIST) | SUCT.SUR. VEL. (WS) | PRES.SUR. VEL. (WP) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .50003 | 1.7500 | .0 | 28.52 | 214.79 | 216.67 | 0.212 | -0.02 | 82.44 | .1958E-02 | 0.0 | 0.0 |
| .58909 | 1.7500 | .89060E-01 | 28.53 | 214.79 | 216.68 | 0.212 | -0.01 | 82.43 | .2653E-02 | 0.0 | 0.0 |
| .67616 | 1.7500 | .17813 | 28.48 | 214.79 | 216.67 | 0.212 | 0.01 | 82.45 | .3277E-02 | 0.0 | 0.0 |
| .76724 | 1.7500 | .26721 | 28.40 | 214.79 | 216.66 | 0.212 | 0.03 | 82.47 | .1070E-02 | 0.0 | 0.0 |
| .85637 | 1.7500 | .35634 | 28.31 | 214.78 | 216.64 | 0.212 | 0.02 | 82.49 | -.5250E-02 | 0.0 | 0.0 |
| .94554 | 1.7500 | .44550 | 28.23 | 214.78 | 216.63 | 0.212 | -0.03 | 82.51 | -.1150E-01 | 0.0 | 0.0 |
| 1.0345 | 1.7499 | .53452 | 28.18 | 214.80 | 216.64 | 0.212 | -0.13 | 82.53 | -.2493E-02 | 0.0 | 0.0 |
| 1.1232 | 1.7498 | .62317 | 28.17 | 214.81 | 216.65 | 0.212 | -0.05 | 82.53 | .2386E-01 | 0.0 | 0.0 |
| 1.2121 | 1.7499 | .71209 | 28.12 | 214.81 | 216.64 | 0.212 | 0.15 | 82.54 | .4209E-01 | 0.0 | 0.0 |
| 1.3022 | 1.7503 | .80221 | 27.98 | 214.75 | 216.56 | 0.212 | 0.33 | 82.58 | -.6127E-02 | 0.0 | 0.0 |
| 1.3925 | 1.7506 | .89248 | 27.87 | 214.70 | 216.50 | 0.212 | 0.03 | 82.60 | -.1128 | 0.0 | 0.0 |
| 1.4803 | 1.7503 | .98031 | 28.20 | 214.75 | 216.60 | 0.212 | -0.76 | 82.52 | -.1438 | 0.0 | 0.0 |
| 1.5661 | 1.7485 | 1.0661 | 29.54 | 214.97 | 216.99 | 0.213 | -1.35 | 82.18 | .6108E-01 | 0.0 | 0.0 |
| 1.6531 | 1.7472 | 1.1531 | 32.42 | 215.14 | 217.57 | 0.213 | -0.12 | 81.43 | .4826 | 0.0 | 0.0 |
| 1.7329 | 1.7485 | 1.2329 | 38.09 | 214.92 | 218.27 | 0.214 | 3.07 | 79.95 | 1.828 | 0.0 | 0.0 |
| 1.7834 | 1.7538 | 1.2836 | 47.14 | 214.32 | 219.44 | 0.215 | 10.47 | 77.60 | 6.372 | 0.0 | 0.0 |
| 1.8049 | 1.7597 | 1.3059 | 53.08 | 213.60 | 220.10 | 0.216 | 20.77 | 76.05 | 8.620 | 0.0 | 0.0 |
| 1.8135 | 1.7634 | 1.3153 | 55.04 | 213.16 | 220.15 | 0.216 | 25.54 | 75.52 | 8.814 | 0.0 | 0.0 |
| 1.8192 | 1.7663 | 1.3218 | 56.17 | 212.80 | 220.09 | 0.216 | 28.78 | 75.21 | 8.636 | 0.0 | 0.0 |
| 1.8269 | 1.7709 | 1.3307 | 57.46 | 212.25 | 219.69 | 0.216 | 33.09 | 74.85 | 8.151 | 0.0 | 0.0 |
| 1.8404 | 1.7810 | 1.3475 | 59.45 | 211.04 | 219.26 | 0.215 | 40.44 | 74.27 | 7.176 | 0.0 | 0.0 |
| 1.8635 | 1.8062 | 1.3820 | 63.38 | 208.10 | 217.54 | 0.213 | 52.91 | 73.06 | 5.455 | 0.0 | 0.0 |
| 1.8951 | 1.8615 | 1.4454 | 72.32 | 201.93 | 214.49 | 0.210 | 66.96 | 70.29 | 3.756 | 0.0 | 0.0 |
| 1.9135 | 1.9455 | 1.5315 | 75.60 | 193.20 | 207.47 | 0.203 | 84.74 | 68.63 | 2.218 | 0.0 | 0.0 |
| 1.9176 | 2.0323 | 1.6183 | 70.34 | 184.96 | 197.88 | 0.194 | 86.80 | 69.18 | .5570 | 0.0 | 0.0 |
| 1.9182 | 2.1176 | 1.7036 | 66.63 | 177.50 | 189.60 | 0.186 | 90.28 | 69.43 | .1992 | 0.0 | 0.0 |
| 1.9173 | 2.2050 | 1.7911 | 62.80 | 170.46 | 181.67 | 0.178 | 90.75 | 69.78 | .1099E-01 | 0.0 | 0.0 |
| 1.9163 | 2.2945 | 1.8806 | 59.69 | 163.82 | 174.35 | 0.171 | 90.37 | 69.98 | -.7967E-01 | 0.0 | 0.0 |
| 1.9161 | 2.3846 | 1.9706 | 57.42 | 157.63 | 167.76 | 0.164 | 89.93 | 69.98 | -.7650E-01 | 0.0 | 0.0 |
| 1.9165 | 2.4747 | 2.0608 | 54.36 | 151.89 | 161.32 | 0.158 | 89.58 | 70.31 | -.5915E-01 | 0.0 | 0.0 |

*** STREAM FUNCTION, INTERIOR VELOCITIES, VELOCITY COMPONENTS, ANGLES, AND SURFACE VELOCITIES ***
ALONG STREAMLINES

* FULL MASSFLOW *
* ITERATION NO. 2 *

** STREAMLINE NUMBER 1 -- STREAM FUNCTION = 0.0 **

| AXIAL COORD. (Z) | RADIAL COORD. (R) | MERID. COORD. (M) | MERID. VEL. (WM) | REL.TANG. VEL. (WTH) | REL. VEL. (W) | CRIT.VEL. RATIO (W/WCR) | MERID. ANGLE (ALPHA) | REL.FLOW ANGLE (BETA) | STREAM. CURV. (1./DIST) | SUCT.SUR. VEL. (WS) | PRES.SUR. VEL. (WP) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .50000 | 1.4167 | .0 | 22.20 | 272.73 | 273.63 | 0.268 | 0.01 | 85.35 | -.9269E-03 | 0.0 | 0.0 |
| .58910 | 1.4167 | .89069E-01 | 22.20 | 272.73 | 273.63 | 0.268 | 0.00 | 85.35 | -.1364E-02 | 0.0 | 0.0 |
| .67518 | 1.4167 | .17815 | 22.26 | 272.73 | 273.64 | 0.268 | -0.00 | 85.33 | -.1375E-02 | 0.0 | 0.0 |
| .76727 | 1.4167 | .26724 | 22.35 | 272.73 | 273.65 | 0.268 | -0.01 | 85.31 | -.3773E-03 | 0.0 | 0.0 |
| .85037 | 1.4166 | .35634 | 22.46 | 272.74 | 273.66 | 0.268 | -0.01 | 85.29 | .1877E-02 | 0.0 | 0.0 |
| .94545 | 1.4166 | .44542 | 22.57 | 272.74 | 273.67 | 0.268 | 0.01 | 85.27 | .5978E-02 | 0.0 | 0.0 |
| 1.0345 | 1.4167 | .53445 | 22.68 | 272.73 | 273.67 | 0.268 | 0.05 | 85.25 | .7208E-02 | 0.0 | 0.0 |
| 1.1235 | 1.4168 | .62343 | 22.82 | 272.71 | 273.66 | 0.268 | 0.06 | 85.22 | -.1715E-01 | 0.0 | 0.0 |
| 1.2126 | 1.4166 | .71253 | 22.91 | 272.71 | 273.67 | 0.268 | -0.12 | 85.20 | -.3337E-01 | 0.0 | 0.0 |
| 1.3020 | 1.4164 | .80199 | 22.86 | 272.79 | 273.74 | 0.268 | -0.23 | 85.21 | .2526E-01 | 0.0 | 0.0 |
| 1.3913 | 1.4162 | .89127 | 22.78 | 272.82 | 273.77 | 0.268 | 0.13 | 85.23 | .1037 | 0.0 | 0.0 |
| 1.4796 | 1.4170 | .97555 | 22.82 | 272.67 | 273.62 | 0.268 | 0.77 | 85.22 | -.1147E-02 | 0.0 | 0.0 |
| 1.5678 | 1.4175 | 1.0678 | 22.54 | 272.50 | 273.43 | 0.268 | 0.12 | 85.27 | -.1932 | 0.0 | 0.0 |
| 1.6575 | 1.4168 | 1.1579 | 21.01 | 272.70 | 273.51 | 0.268 | -1.22 | 85.59 | -.5237E-01 | 0.0 | 0.0 |
| 1.7486 | 1.4152 | 1.2486 | 18.08 | 273.01 | 273.61 | 0.268 | -0.40 | 86.21 | .4869 | 0.0 | 0.0 |
| 1.8355 | 1.4170 | 1.3359 | 14.00 | 272.06 | 273.02 | 0.268 | 3.62 | 87.06 | 1.801 | 0.0 | 0.0 |
| 1.9133 | 1.4207 | 1.4142 | 10.07 | 270.43 | 270.62 | 0.265 | 15.71 | 87.87 | 4.878 | 0.0 | 0.0 |
| 1.9721 | 1.4540 | 1.4603 | 8.14 | 264.83 | 264.75 | 0.260 | 41.32 | 88.24 | 6.516 | 0.0 | 0.0 |
| 2.0050 | 1.5115 | 1.5143 | 8.81 | 255.62 | 255.77 | 0.251 | 67.47 | 88.03 | 5.665 | 0.0 | 0.0 |
| 2.0253 | 1.5835 | 1.6186 | 12.53 | 243.93 | 244.26 | 0.239 | 84.34 | 87.06 | 2.757 | 0.0 | 0.0 |
| 2.0276 | 1.6706 | 1.7053 | 20.37 | 231.27 | 232.17 | 0.228 | 91.05 | 84.97 | .7070 | 0.0 | 0.0 |
| 2.0252 | 1.7621 | 1.7769 | 32.13 | 219.26 | 221.60 | 0.217 | 91.20 | 81.66 | -.9057E-01 | 0.0 | 0.0 |
| 2.0242 | 1.8522 | 1.8370 | 44.13 | 208.00 | 213.23 | 0.209 | 90.12 | 78.04 | -.1660 | 0.0 | 0.0 |
| 2.0246 | 1.9469 | 1.9757 | 50.72 | 199.06 | 205.42 | 0.201 | 89.49 | 75.70 | -.7857E-01 | 0.0 | 0.0 |
| 2.0255 | 2.0290 | 2.0638 | 51.10 | 190.42 | 197.16 | 0.193 | 89.33 | 74.98 | .1153E-01 | 0.0 | 0.0 |
| 2.0264 | 2.1172 | 2.1520 | 49.04 | 182.49 | 188.96 | 0.185 | 89.61 | 74.96 | .6453E-01 | 0.0 | 0.0 |
| 2.0267 | 2.2060 | 2.2408 | 46.65 | 175.14 | 181.25 | 0.178 | 89.98 | 75.09 | .5953E-01 | 0.0 | 0.0 |
| 2.0265 | 2.2953 | 2.3300 | 44.58 | 168.33 | 174.14 | 0.171 | 90.22 | 75.17 | .3852E-01 | 0.0 | 0.0 |
| 2.0261 | 2.3848 | 2.4196 | 43.04 | 162.01 | 167.63 | 0.164 | 90.37 | 75.12 | .2617E-01 | 0.0 | 0.0 |
| 2.0254 | 2.4746 | 2.5094 | 41.97 | 156.14 | 161.68 | 0.156 | 90.49 | 74.95 | .1746E-01 | 0.0 | 0.0 |

** STREAMLINE NUMBER 2 -- STREAM FUNCTION = 0.0500 **

| AXIAL COORD. (Z) | RADIAL COORD. (R) | MERID. COORD. (M) | MERID. VEL. (WM) | REL.TANG. VEL. (WTH) | REL. VEL. (W) | CRIT.VEL. RATIO (W/WCR) | MERID. ANGLE (ALPHA) | REL.FLOW ANGLE (BETA) | STREAM. CURV. (1./DIST) | SUCT.SUR. VEL. (WS) | PRES.SUR. VEL. (WP) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .50000 | 1.4351 | .0 | 22.12 | 269.27 | 270.18 | 0.265 | 0.02 | 85.30 | -.7068E-02 | 0.0 | 0.0 |
| .58910 | 1.4351 | .89071E-01 | 22.12 | 269.27 | 270.18 | 0.265 | -0.01 | 85.30 | -.6401E-02 | 0.0 | 0.0 |
| .67518 | 1.4350 | .17815 | 22.18 | 269.28 | 270.19 | 0.265 | -0.04 | 85.29 | -.4456E-02 | 0.0 | 0.0 |
| .76727 | 1.4349 | .26725 | 22.26 | 269.29 | 270.21 | 0.265 | -0.06 | 85.27 | -.1470E-02 | 0.0 | 0.0 |
| .85037 | 1.4348 | .35634 | 22.36 | 269.31 | 270.24 | 0.265 | -0.06 | 85.25 | .1431E-02 | 0.0 | 0.0 |
| .94545 | 1.4348 | .44542 | 22.45 | 269.33 | 270.26 | 0.265 | -0.04 | 85.23 | .4811E-02 | 0.0 | 0.0 |
| 1.0345 | 1.4347 | .53444 | 22.56 | 269.34 | 270.28 | 0.265 | -0.01 | 85.21 | .4073E-02 | 0.0 | 0.0 |
| 1.1234 | 1.4347 | .62341 | 22.69 | 269.34 | 270.29 | 0.265 | -0.00 | 85.19 | -.1179E-01 | 0.0 | 0.0 |
| 1.2126 | 1.4346 | .71257 | 22.77 | 269.36 | 270.32 | 0.265 | -0.13 | 85.17 | -.2339E-01 | 0.0 | 0.0 |
| 1.3021 | 1.4343 | .80209 | 22.72 | 269.42 | 270.37 | 0.265 | -0.24 | 85.18 | .2957E-01 | 0.0 | 0.0 |
| 1.3913 | 1.4342 | .89125 | 22.64 | 269.44 | 270.39 | 0.265 | 0.16 | 85.20 | .3956E-01 | 0.0 | 0.0 |
| 1.4793 | 1.4345 | .97531 | 22.66 | 269.30 | 270.25 | 0.265 | 0.77 | 85.19 | .3688E-01 | 0.0 | 0.0 |
| 1.5677 | 1.4360 | 1.0677 | 22.35 | 269.10 | 270.02 | 0.265 | 0.53 | 85.25 | -.7565E-01 | 0.0 | 0.0 |
| 1.6582 | 1.4363 | 1.1582 | 20.87 | 267.04 | 269.85 | 0.264 | 0.62 | 85.56 | .1639 | 0.0 | 0.0 |
| 1.7486 | 1.4378 | 1.2480 | 18.08 | 266.76 | 269.37 | 0.264 | 2.39 | 86.15 | .9034 | 0.0 | 0.0 |
| 1.8338 | 1.4457 | 1.3342 | 14.35 | 267.28 | 267.67 | 0.262 | 9.33 | 86.93 | 2.578 | 0.0 | 0.0 |
| 1.9029 | 1.4653 | 1.4060 | 11.26 | 263.67 | 263.91 | 0.259 | 24.40 | 87.55 | 5.418 | 0.0 | 0.0 |
| 1.9455 | 1.4927 | 1.4575 | 10.34 | 253.69 | 253.90 | 0.254 | 43.05 | 87.71 | 6.209 | 0.0 | 0.0 |
| 1.9750 | 1.5307 | 1.5046 | 11.12 | 252.42 | 252.67 | 0.248 | 59.74 | 87.48 | 5.265 | 0.0 | 0.0 |

** STREAMLINE NUMBER 21 -- STREAM FUNCTION = 0.9500 **

| AXIAL COORD. (Z) | RADIAL COORD. (R) | MERID. COORD. (M) | MERID. VEL. (WM) | REL.TANG. VEL. (WTH) | REL. VEL. (W) | CRIT.VEL. RATIO (W/WCR) | MERID. ANGLE (ALPHA) | REL.FLOW ANGLE (BETA) | STREAM. CURV. (1./DIST) | SUCT.SUR. VEL. (WS) | PRES.SUR. VEL. (WP) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .50003 | 1.7348 | .0 | 21.72 | 222.74 | 223.79 | 0.219 | -0.01 | 84.43 | -.4276E-02 | 0.0 | 0.0 |
| .59409 | 1.7348 | .39062E-01 | 21.72 | 222.74 | 223.80 | 0.219 | -0.02 | 84.43 | -.2408E-02 | 0.0 | 0.0 |
| .67616 | 1.7347 | .17314 | 21.66 | 222.75 | 223.80 | 0.219 | -0.03 | 84.45 | .2652E-03 | 0.0 | 0.0 |
| .76725 | 1.7347 | .26722 | 21.57 | 222.75 | 223.79 | 0.219 | -0.02 | 84.47 | -.5458E-04 | 0.0 | 0.0 |
| .85837 | 1.7347 | .35635 | 21.47 | 222.76 | 223.79 | 0.219 | -0.03 | 84.49 | -.5134E-02 | 0.0 | 0.0 |
| .94953 | 1.7346 | .44550 | 21.37 | 222.77 | 223.79 | 0.219 | -0.07 | 84.52 | -.9557E-02 | 0.0 | 0.0 |
| 1.0345 | 1.7344 | .53449 | 21.30 | 222.79 | 223.80 | 0.219 | -0.13 | 84.54 | -.8766E-03 | 0.0 | 0.0 |
| 1.1232 | 1.7342 | .62316 | 21.25 | 222.81 | 223.82 | 0.219 | -0.08 | 84.55 | .2205E-01 | 0.0 | 0.0 |
| 1.2122 | 1.7342 | .71213 | 21.18 | 222.81 | 223.81 | 0.219 | 0.10 | 84.57 | .3732E-01 | 0.0 | 0.0 |
| 1.3023 | 1.7346 | .80230 | 21.04 | 222.77 | 223.76 | 0.219 | 0.30 | 84.61 | -.8357E-03 | 0.0 | 0.0 |
| 1.3925 | 1.7345 | .89249 | 20.94 | 222.72 | 223.70 | 0.219 | 0.09 | 84.63 | -.8250E-01 | 0.0 | 0.0 |
| 1.4501 | 1.7346 | .98010 | 21.16 | 222.76 | 223.76 | 0.219 | -0.53 | 84.57 | -.4235E-01 | 0.0 | 0.0 |
| 1.5058 | 1.7336 | 1.0657 | 22.08 | 222.90 | 223.95 | 0.220 | -0.74 | 84.34 | .1529 | 0.0 | 0.0 |
| 1.6531 | 1.7335 | 1.1331 | 24.12 | 222.90 | 224.20 | 0.220 | 0.97 | 83.82 | .5000 | 0.0 | 0.0 |
| 1.7335 | 1.7374 | 1.2336 | 28.14 | 222.41 | 224.18 | 0.220 | 4.63 | 82.79 | 2.035 | 0.0 | 0.0 |
| 1.7652 | 1.7447 | 1.2658 | 34.54 | 221.46 | 224.14 | 0.220 | 12.93 | 81.14 | 5.752 | 0.0 | 0.0 |
| 1.8078 | 1.7521 | 1.3096 | 36.65 | 220.55 | 223.92 | 0.219 | 22.41 | 80.01 | 7.672 | 0.0 | 0.0 |
| 1.8169 | 1.7563 | 1.3196 | 40.37 | 219.99 | 223.67 | 0.219 | 26.87 | 79.60 | 7.935 | 0.0 | 0.0 |
| 1.8229 | 1.7557 | 1.3265 | 41.27 | 219.58 | 223.42 | 0.219 | 29.95 | 79.36 | 7.806 | 0.0 | 0.0 |
| 1.8309 | 1.7647 | 1.3359 | 42.33 | 218.95 | 223.01 | 0.219 | 34.05 | 79.06 | 7.510 | 0.0 | 0.0 |
| 1.8450 | 1.7756 | 1.3538 | 44.01 | 217.60 | 222.01 | 0.218 | 41.37 | 78.57 | 6.763 | 0.0 | 0.0 |
| 1.8691 | 1.8022 | 1.3897 | 47.35 | 214.38 | 219.55 | 0.215 | 53.45 | 77.55 | 5.231 | 0.0 | 0.0 |
| 1.9033 | 1.8555 | 1.4549 | 54.53 | 207.79 | 214.52 | 0.211 | 68.55 | 75.30 | 3.718 | 0.0 | 0.0 |
| 1.9186 | 1.9450 | 1.5424 | 57.31 | 193.64 | 206.75 | 0.203 | 83.83 | 73.91 | 1.876 | 0.0 | 0.0 |
| 1.9228 | 2.0321 | 1.6296 | 53.70 | 190.13 | 197.57 | 0.194 | 89.03 | 74.23 | .6191 | 0.0 | 0.0 |
| 1.9235 | 2.1176 | 1.7150 | 50.92 | 182.45 | 189.43 | 0.186 | 90.14 | 74.41 | .1670 | 0.0 | 0.0 |
| 1.9226 | 2.2051 | 1.8025 | 48.04 | 175.22 | 181.68 | 0.178 | 90.72 | 74.67 | .2254E-01 | 0.0 | 0.0 |
| 1.9218 | 2.2745 | 1.8920 | 45.67 | 168.39 | 174.47 | 0.171 | 90.35 | 74.82 | -.7717E-01 | 0.0 | 0.0 |
| 1.9215 | 2.3846 | 1.9820 | 43.95 | 162.03 | 167.88 | 0.165 | 89.93 | 74.83 | -.8019E-01 | 0.0 | 0.0 |
| 1.9220 | 2.4747 | 2.0721 | 41.98 | 156.13 | 161.67 | 0.158 | 89.52 | 74.95 | -.7813E-01 | 0.0 | 0.0 |

** STREAMLINE NUMBER 22 -- STREAM FUNCTION = 1.0000 **

| AXIAL COORD. (Z) | RADIAL COORD. (R) | MERID. COORD. (M) | MERID. VEL. (WM) | REL.TANG. VEL. (WTH) | REL. VEL. (W) | CRIT.VEL. RATIO (W/WCR) | MERID. ANGLE (ALPHA) | REL.FLOW ANGLE (BETA) | STREAM. CURV. (1./DIST) | SUCT.SUR. VEL. (WS) | PRES.SUR. VEL. (WP) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| .50003 | 1.7500 | .0 | 21.68 | 220.78 | 221.85 | 0.217 | -0.02 | 84.39 | .1958E-02 | 0.0 | 0.0 |
| .58709 | 1.7500 | .89060E-01 | 21.69 | 220.79 | 221.85 | 0.217 | -0.01 | 84.39 | .2653E-02 | 0.0 | 0.0 |
| .67616 | 1.7500 | .17313 | 21.62 | 220.79 | 221.84 | 0.217 | 0.01 | 84.41 | .3277E-02 | 0.0 | 0.0 |
| .76724 | 1.7500 | .26721 | 21.52 | 220.78 | 221.83 | 0.217 | 0.03 | 84.43 | .1370E-02 | 0.0 | 0.0 |
| .85837 | 1.7500 | .35534 | 21.41 | 220.78 | 221.81 | 0.217 | 0.02 | 84.46 | -.5250E-02 | 0.0 | 0.0 |
| .94954 | 1.7500 | .44550 | 21.30 | 220.78 | 221.80 | 0.217 | -0.03 | 84.49 | -.1150E-01 | 0.0 | 0.0 |
| 1.0345 | 1.7495 | .53502 | 21.22 | 220.79 | 221.81 | 0.217 | -0.10 | 84.51 | -.2493E-02 | 0.0 | 0.0 |
| 1.1232 | 1.7498 | .62317 | 21.17 | 220.81 | 221.82 | 0.217 | -0.05 | 84.52 | .2366E-01 | 0.0 | 0.0 |
| 1.2121 | 1.7495 | .71209 | 21.09 | 220.80 | 221.81 | 0.217 | 0.15 | 84.54 | .4207E-01 | 0.0 | 0.0 |
| 1.3022 | 1.7503 | .80721 | 20.93 | 220.74 | 221.73 | 0.217 | 0.30 | 84.58 | -.6127E-02 | 0.0 | 0.0 |
| 1.3925 | 1.7506 | .89748 | 20.81 | 220.64 | 221.67 | 0.217 | 0.03 | 84.61 | -.1128 | 0.0 | 0.0 |
| 1.4303 | 1.7503 | .98031 | 21.03 | 220.75 | 221.74 | 0.217 | -0.76 | 84.56 | -.1438 | 0.0 | 0.0 |
| 1.5061 | 1.7485 | 1.0661 | 22.02 | 220.97 | 222.06 | 0.218 | -1.35 | 84.31 | .6138E-01 | 0.0 | 0.0 |
| 1.6331 | 1.7472 | 1.1331 | 24.23 | 221.14 | 222.47 | 0.218 | -0.12 | 83.75 | .4826 | 0.0 | 0.0 |
| 1.7129 | 1.7489 | 1.2329 | 28.61 | 220.92 | 222.76 | 0.218 | 3.07 | 82.62 | 1.828 | 0.0 | 0.0 |
| 1.7834 | 1.7538 | 1.2836 | 35.64 | 220.33 | 223.17 | 0.219 | 10.47 | 80.41 | 6.372 | 0.0 | 0.0 |
| 1.8045 | 1.7597 | 1.3059 | 40.27 | 219.55 | 223.23 | 0.219 | 20.77 | 79.61 | 8.629 | 0.0 | 0.0 |
| 1.8135 | 1.7634 | 1.3153 | 41.82 | 219.11 | 223.06 | 0.219 | 25.54 | 79.13 | 8.814 | 0.0 | 0.0 |
| 1.8192 | 1.7663 | 1.3218 | 42.72 | 218.74 | 222.87 | 0.218 | 28.78 | 78.95 | 8.636 | 0.0 | 0.0 |
| 1.8269 | 1.7709 | 1.3307 | 43.75 | 218.17 | 222.52 | 0.218 | 33.09 | 78.66 | 8.151 | 0.0 | 0.0 |
| 1.8404 | 1.7810 | 1.3475 | 45.36 | 216.95 | 221.62 | 0.217 | 40.44 | 78.19 | 7.176 | 0.0 | 0.0 |
| 1.8635 | 1.8062 | 1.3820 | 48.50 | 213.91 | 219.34 | 0.215 | 52.91 | 77.23 | 5.455 | 0.0 | 0.0 |
| 1.8951 | 1.8615 | 1.4454 | 55.42 | 207.56 | 214.83 | 0.211 | 68.55 | 75.05 | 3.756 | 0.0 | 0.0 |
| 1.9135 | 1.9455 | 1.5315 | 57.39 | 193.60 | 206.86 | 0.203 | 84.74 | 73.75 | 2.218 | 0.0 | 0.0 |
| 1.9176 | 2.0323 | 1.6183 | 53.86 | 190.12 | 197.60 | 0.194 | 88.80 | 74.18 | .5570 | 0.0 | 0.0 |
| 1.9182 | 2.1176 | 1.7036 | 51.02 | 182.46 | 189.46 | 0.186 | 90.28 | 74.38 | .1992 | 0.0 | 0.0 |
| 1.9173 | 2.2050 | 1.7911 | 48.10 | 175.22 | 181.70 | 0.178 | 90.75 | 74.65 | .1099E-01 | 0.0 | 0.0 |
| 1.9163 | 2.2945 | 1.8806 | 45.72 | 168.39 | 174.49 | 0.171 | 90.37 | 74.81 | -.7967E-01 | 0.0 | 0.0 |
| 1.9161 | 2.3846 | 1.9706 | 43.98 | 162.03 | 167.89 | 0.165 | 89.93 | 74.81 | -.7650E-01 | 0.0 | 0.0 |
| 1.9165 | 2.4747 | 2.0608 | 41.64 | 156.13 | 161.58 | 0.158 | 89.58 | 75.07 | -.5915E-01 | 0.0 | 0.0 |

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